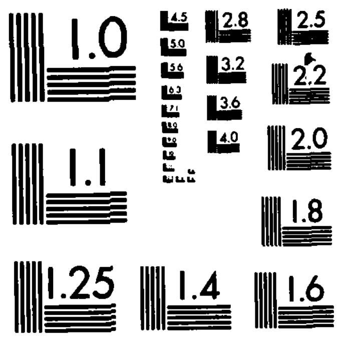
AD-A159 893 PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBIL..(U) COORDINATING RESEARCH COUNCIL INC ATLANTA GA JAN 84 CRC-536 DAAK70-81-C-0128

1/3

UNCLASSIFIED

F/G 21/4 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A159 893

DTIC ACCESSION NUMBER

PHOTOGRAPH THIS SHEET

II

LEVEL

1

INVENTORY

CRC Rept #536

DOCUMENT IDENTIFICATION

JAN 1984

This document has been approved for public release and sale; its distribution is unlimited.

DISTRIBUTION STATEMENT

ACCESSION FOR	
NTIS GRA&I	☒
DTIC TAB	☐
UNANNOUNCED	☐
JUSTIFICATION	
BY	
DISTRIBUTION /	
AVAILABILITY CODES	
DIST	AVAIL AND/OR SPECIAL
A-1	

DISTRIBUTION STAMP

DTIC COPY INSPECTED 5

DTIC SELECTED SEP 26 1985 S E D

DATE ACCESSIONED

DATE RETURNED

85 9 26 008

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NO.

DTIC FILE COPY

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

DTIC FORM 70A DEC 83

DOCUMENT PROCESSING SHEET

PREVIOUS EDITION MAY BE USED UNTIL STOCK IS EXHAUSTED.

CRC Report No. 536

PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBILES PHASE II METHANOL-GASOLINE BLENDS

January 1984

DAAK 70-81-C-0128

COORDINATING RESEARCH COUNCIL, INC.
219 PERIMETER CENTER PARKWAY, ATLANTA, GEORGIA 30346

COORDINATING RESEARCH COUNCIL
INCORPORATED
219 PERIMETER CENTER PARKWAY
ATLANTA, GEORGIA 30346
(404) 396-3400

January 25, 1984

CRC Project No. CM-125-78

W26R9D
USAMERADCOM
Energy and Water Resources Laboratory
ATTN: DRDME-WC
Fort Belvoir, Virginia 22060

Gentlemen:

In accordance with the requirements stated in Contract Number DAAK-70-81-C-0128, enclosed are two copies of the following report which has been approved by the appropriate CRC Committee for transmittal to the Military and release for publication and general distribution by the Sustaining Members:

PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBILES: PHASE II - METHANOL-GASOLINE BLENDS
(CRC Report No. 536)

Sincerely,

Beth Evans
Editor

BE:sb

Enclosures

COORDINATING RESEARCH COUNCIL
INCORPORATED
219 PERIMETER CENTER PARKWAY
ATLANTA, GEORGIA 30346
(404) 396-3400

Contractor Report
DE-AC03-79CS50003

PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBILES PHASE II - METHANOL-GASOLINE BLENDS

(CRC PROJECT No. CM-125-78)

FINAL REPORT OF SYSTEMS CONTROL, INC.

This report covers the results of an information search funded by the US Department of Energy through DOE/CRC Contract No. DE-AC03-79CS50003, and conducted under the guidance of the CRC Group on Alternative Automotive Fuels. The CRC Group analyzed the data, wrote the portion of the report pertaining to data interpretation, and reviewed the remainder of the report, which was written by SCI.

January 1984

Light-Duty Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

ABSTRACT

The Coordinating Research Council, Inc. (CRC) conducted a test program designed to define the emissions, fuel economy, driveability, and vapor lock characteristics of both simple and volatility-adjusted ethanol-gasoline (Phase I) and methanol-gasoline (Phase II) blends versus gasoline. The fuels were tested in 1980 model-year cars representing various emission-control technologies using test procedures accepted by the Federal Government and Industry. This report details the methanol-gasoline blends portion of the program. Six unleaded fuels were used for this phase of the program: a reference gasoline and five methanol blends. The methanol-gasoline blends had oxygen contents ranging between 1 and 8 weight percent, and included fuels with and without isobutanol co-solvent. Ten of the fourteen 1980 model cars from the Phase I portion of the program were re-used in Phase II, following renovation, re-inspection, and acceptance by CRC. The study showed that methanol in gasoline affected most vehicle performance parameters. Organic and carbon monoxide tailpipe emissions were reduced, but effects on other emissions, driveability, and fuel economy were generally adverse with methanol at the higher concentrations. Another experimental program is needed to define the response of vehicle performance factors to fuel characteristics such as oxygen content and volatility, which this program strongly suggests are the two most influential on vehicle performance.

ACKNOWLEDGEMENT

This project was sponsored by the US Department of Energy under Contract DE-AC03-79CS50003 with the Coordinating Research Council, Inc. The project was performed by Systems Control, Inc., under Contract CM-125-1-79 with the Coordinating Research Council, Inc. Two consultants were employed by the Coordinating Research Council to assist with the data analysis and report-drafting: D. S. Gray, and Gunstat Research and Analysis, Inc. This report has been reviewed by the Coordinating Research Council and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of either the Coordinating Research Council or the US Department of Energy; nor does mention of trade names, commercial products, or organizations constitute endorsement or recommendation for use or non-use.

TABLE OF CONTENTS

		Page
ABSTRACT		i
ACKNOWLEDGEMENT		iii
SECTION 1 - SUMMARY		
1.1	Background	3
1.2	Test Program	3
1.3	Results and Conclusions	5
SECTION 2 - VEHICLES		
2.1	Selection	9
2.2	Preparation	10
2.3	Vehicle Maintenance	10
2.3.1	Scheduled Maintenance	10
2.3.2	Unscheduled Maintenance	12
SECTION 3 - FUELS		
3.1	Trial Blends	17
3.2	Test Fuel Specifications	25
3.3	Blending Procedures	25
3.4	Fuel Storage	27
3.5	Inspection Results	27
3.6	Carbon-Balance Fuel Economy	29
SECTION 4 - TEST METHODOLOGY		
4.1	Laboratory Description	33
4.1.1	Sample Collection for Aldehydes and Alcohol Emissions	33
4.1.2	Sample Analysis	34
4.1.3	Vapor Lock Test Cell	35
4.2	Emission Testing	36
4.2.1	Carbon Canister Preconditioning	36
4.2.2	Vehicle Preconditioning	36
4.2.3	Federal Test Procedure (FTP) with Evaporative (SHED) Emissions	38
4.2.4	Highway Fuel Economy Test Procedure (HFET)	39

TABLE OF CONTENTS - (Continued)

Page

SECTION 4 - TEST METHODOLOGY (Continued)

4.3 Cold-Start Driveability Testing........................ 39
4.4 Vapor Lock Testing..................................... 39
4.5 Quality Assurance...................................... 40
4.5.1 Laboratory Checkout.................................. 40
4.5.2 Periodic Calibrations................................ 40
4.5.3 Test Data Audit...................................... 40

SECTION 5 - RESULTS

5.1 Treatment of Test Data................................. 43
5.2 Statistical Analysis Methodology....................... 44
5.3 Interpretation of Analysis of Variance Results......... 50
5.4 Discussion of Results.................................. 54
5.4.1 FTP Organic Emissions................................ 54
5.4.2 FTP CO Emissions..................................... 54
5.4.3 FTP NO_x Emissions................................. 54
5.4.4 Methanol Emissions................................... 58
5.4.5 Aldehyde Emissions................................... 58
5.4.6 SHED Organic Emissions............................... 58
5.4.7 SHED Methanol Emissions.............................. 58
5.4.8 Driveability.. 58
5.4.9 Vapor Lock... 63
5.4.10 Fuel and Energy Economy............................. 63
5.5 Implications and Need for Additional Study............. 63

REFERENCES... 69

LIST OF TABLES

TABLE		Page
2-1	- Test Vehicle Description	11
2-2	- Unscheduled Maintenance for Phase II	13/14
3-1	- Methanol-Gasoline Blends for Laboratory Testing	19
3-2	- Water Tolerance of Trial Blends	20
3-3	- RVP's for Trial Blends	22
3-4	- Changes in Vapor/Liquid Ratios Between Methanol and Methanol/Isobutanol Blends	23
3-5	- Hydrocarbon Composition of Fuels for Trial Blends	24
3-6	- Blending Targets for Phase II Methanol-Gasoline Fuels	26
3-7	- Test Fuel Inspections	28
3-8	- Carbon-Balance Fuel Economy Parameters for Phase II	30
5-1	- Number of Replicates for Each Fuel, Group, Model and Car Combination	49
5-2	- Summary of Analysis of Variance Results	51
5-3	- Summary of Means for Data Groups Defined by Analysis of Variance Results	52
5-4	- Significant Changes for Selected Fuel Pairs	53

LIST OF FIGURES

FIGURE		Page
3-1	- Water Tolerance of MB2 Base Stock Trial Blends and Water Tolerance of Test Blends	21
4-1	- Emission Test Sequence	37
5-1	- FTP Organics, g/mi	55
5-2	- FTP CO, g/mi	56
5-3	- FTP NO_x, g/mi	57
5-4	- FTP Methanol, mg/mi	59
5-5	- SHED Organics, g/test	60
5-6	- SHED Methanol, g/test	61
5-7	- Driveability, Total Weighted Demerits	62
5-8	- Combined Fuel Economy, mpg	65
5-9	- Combined Energy Economy, mi/MBtu	66

APPENDICES

Page

APPENDIX A - Membership: CRC Alternative Automotive Fuels Group and Panels.....A-1

APPENDIX B - Test Data.....B-1

APPENDIX C - Fuel Properties.....C-1

APPENDIX D - Test Facilities.....D-1

APPENDIX E - Test Procedures.....E-1

APPENDIX F - Quality Assurance.....F-1

APPENDIX G - Detailed Results of Analysis of Variance.....G-1

APPENDIX H - Fuel and Energy Economy: Separate Highway and City FTP Results.....H-1

Section 3

FUELS

This section discusses the selection, preparation, and properties of the one gasoline and five methanol-gasoline blends used for Phase II. Rather than simply adding methanol to gasoline, volatility of the blends was tailored in a manner consistent with that expected for a finished commercial fuel. Test fuel composition was specified by the Fuel Selection Panel of the CRC Alternative Automotive Fuels Group. The Panel was composed of members of the automotive and petroleum refining industries who were active in testing and evaluation of alcohol fuels. Separate paragraphs are devoted to the following topics:

- Trial Blends
- Test Fuel Specifications
- Blending Procedures
- Inspection Results
- Fuel Storage
- Carbon-Balance Fuel Economy

3.1 TRIAL BLENDS

Prior to specifying the test fuels, a set of twenty-four trial blends were prepared. A number of physical and chemical tests were conducted to determine the effect of methanol and co-solvent on fuel properties. The physical tests included the following:

- RVP (modified method)
- D 86 Distillation
- V/L Ratio (temperatures for V/L of 5, 10, 15, 20, 25, 30, and 35)
- Water Tolerance at 20°C, 5°C, and -15°C
- Research and Motor octane ratings
- API Gravity

SECTION 3

FUELS

TABLE 2-2. UNSCHEDULED MAINTENANCE FOR PHASE II

(Continued)

VEHICLE	MILEAGE	PROBLEM	MAINTENANCE ACTION
06-1	5,434	Preparation for Phase II testing	Oil change; reset (enrich) idle mixture
	5,736	High NO_x emissions on base	Replaced EGR valve
	6,002	Stalling/high evaporative emissions using MG-3	Replaced leaking Fluidyne
	7,619	Leaking Fluidyne	Replaced Fluidyne
C6-1	5,567	Preparation for Phase II testing	Oil change; adjusted idle speed (+30 rpm)
	5,699	High NO_x emissions on base	Replaced EGR valve
	6,102	Leaking Fluidyne	Replaced Fluidyne

TABLE 2-2. UNSCHEDULED MAINTENANCE FOR PHASE II

VEHICLE	MILEAGE	PROBLEM	MAINTENANCE ACTION
04-1	6,328	Preparation for Phase II testing	Oil change; adjust idle speed (-50 rpm) reset (enrichen) idle mixture
04-2	6,499	Preparation for Phase II testing	Oil change; adjust idle speed (+160 rpm)
C4-1	5,761	Preparation for Phase II testing	Oil change; adjusted idle speed (-150 rpm)
	6,017	High evaporative emissions	Replaced leaking quick connect fitting
	6,786	Stalled using MG-2 and would not restart	Replaced leaking carburetor spacer gasket
	6,839	Fuel leak	Repaired Fluidyne leak
C4-2	5,633	Preparation for Phase II testing	Oil change; adjusted idle speed (-30 rpm)
	6,481	Stalling and hesitation using MG-5 during FTP	Corrected vacuum hose leak
	6,490	High evaporative emissions	Replaced leaking Fluidyne
	6,633	Stalled on MG-3 and would not restart (beginning of driveability test)	Replaced leaking carburetor gasket and carburetor (idle passages had been plugged with sealer from closed-loop control system's fuel enrichment solenoid)
04-3	6,072	Preparation for Phase II testing	Oil change, adjust idle speed (+25 rpm)
04-4	6,127	Preparation for Phase II testing	Oil change, reset (enriched) idle mixture
	6,369	High evaporative emissions	Repaired Fluidyne leak
C4-3	7,198	Preparation for Phase II testing	Oil change; adjusted idle speed (+25 rpm)
	7,403	High cold start HC and CO emissions using MG-1	Readjusted idle mixture (enleaned) using base gasoline
	7,539	High cold start HC and CO emissions using MG-4, stalling when warmed up	Replaced microprocessor and idle solenoid (dealer repair) then repeated affected tests (MG-1, MG-4)
C4-4	6,115	Preparation for Phase II testing	Oil change; adjusted idle speed (+75 rpm)

2.3.2 Unscheduled Maintenance

Unscheduled maintenance comprised any adjustment, repair, or replacement of parts not included in scheduled maintenance as described above. Unscheduled emission-related maintenance included correction of engine, fuel, emissions, and exhaust system component failures or maladjustments. Unscheduled maintenance was performed any time a component was determined to be malfunctioning. Component failure or malfunction was typically detected by emissions data abnormalities or vehicle driveability during testing. Emission data abnormalities included failure of emissions standards either at zero miles or during testing of base fuel after 4,000 miles. Vehicle driveability problems included stalling, hesitation, and stumble. In general, driveability problems were corrected by fuel pump or Fluidyne fuel flow transducer replacements. When component replacements or adjustments were made (other than fuel pump or filter replacements), the vehicle was tested after repair, and the data were compared with previous results to verify that emission changes had not occurred. Several vehicles encountered methanol-related failures of the fuel induction system and, in particular, of the Fluidyne transducer, which leaked in some occasions.

It is unlikely that the leaking Fluidynes influenced the analyzed results because the results with the leaking Fluidyne were discarded, and examination of test results before and after Fluidyne replacement and/or repair showed no anomalies in any of the data. For example, on page B-18, Car 06-1 had SHED organic emissions on the same fuel of 5.9 before the leak developed, and 6.2 after the leak developed and was corrected.

In several cases, component defects were not detected using functional checks, although unusually high emission levels were encountered. After reviewing the emission data, these vehicles were removed from the test schedule and subjected to further diagnostic procedures to identify the malfunctioning components. Manufacturer representatives were contacted for advice and direction when SCI personnel were unable to identify a reason for the emission failure. Table 2-2 summarizes unscheduled maintenance actions.

TABLE 2-1. TEST VEHICLE DESCRIPTION

MAKE	MODEL	VEHICLE ID. NUMBER	CONTROL SYSTEM[1]	FUEL SYSTEM	ENGINE SIZE[2]	NO. OF CYLINDERS	INERTIA WEIGHT[3]	TEST HORSEPOWER[4]
Plymouth	Horizon	ML24AAD102722	Open	Carburetion	1.7	4	2,625	6.8
Plymouth	Horizon	ML24AAD186511	Open	Carburetion	1.7	4	2,625	6.8
Dodge	Omni	ZL24AAD230652	Closed	Carburetion	1.7	4	2,625	6.8
Dodge	Omni	ZL24AAD230651	Closed	Carburetion	1.7	4	2,625	6.8
Ford	Pinto	0T10A142387	Open	Carburetion	2.3	4	3,000	9.7
Ford	Pinto	0T10A149924	Open	Carburetion	2.3	4	3,000	9.7
Ford	Pinto	0T10A152198	Closed	Carburetion	2.3	4	3,000	9.7
Ford	Pinto	0T10A152199	Closed	Carburetion	2.3	4	3,000	9.7
Buick	Century	4L69AAC116703	Open	Carburetion	3.8	6	3,500	11.3
Buick	Century	4L69AAC116617	Closed	Carburetion	3.8	6	3,500	11.3

NOTES:

[1] Open-loop cars were calibrated for 1980 Federal emission standards. Closed-loop cars were calibrated for 1980 California emission standards.

[2] Engine size in liters

[3] Vehicle inertia weight in pounds

[4] Actual road-load test horsepower at 50 miles per hour (emissions and vapor lock tests)

The experimental design shown in Table 2-1 was a compromise providing a total of ten cars from the Phase I program which retained the three models with open- and closed-loop systems and duplicated the four-cylinder engines. The vehicle fleet did not statistically represent either the 1980 model-year vehicle population or the general vehicle population; therefore, the test design could not quantitatively predict the effects of alcohol-gasoline blends on the general vehicle population. Furthermore, the test fleet was not large enough to permit the evaluation of vehicle-to-vehicle variability on the observed effects of alcohol-gasoline blends. The ten vehicles will be referred to by an alphanumeric code in data presentation. The first symbol defines the emission control system (O for open-loop and C for closed-loop). The second symbol defines the number of cylinders (4 or 6). The third symbol defines the number of the vehicle of the category (1, 2, 3, or 4). The three car models will be referred to by the vehicle code O, P, and C.

2.2 PREPARATION

Details of the initial inspections and preparation procedures of the vehicles are described in CRC Report No. 527[1] on the ethanol-gasoline blends (Phase I) portion of the program.

2.3 VEHICLE MAINTENANCE

Vehicle maintenance was performed on a scheduled and unscheduled basis. Scheduled maintenance was performed at intervals as specified in the respective manufacturers' owner's manuals. Unscheduled maintenance was performed whenever a particular condition arose requiring correction in the interest of safety, operational efficiency, or emission data consistency. All work performed on a given vehicle was entered in the respective vehicle's log book.

2.3.1 Scheduled Maintenance

Scheduled maintenance included routine servicing of vehicles during mileage accumulation and testing, and parameter and component checks performed upon receipt at zero miles, at the beginning of Phase I testing after break-in and at the beginning of Phase II testing. No vehicle received major scheduled engine or mechanical maintenance. Sample vehicle inspection forms are shown in Appendix E.

Section 2

VEHICLES

This section describes the selection, procurement, and preparation of the test vehicles used.

2.1 SELECTION

Considering the possibility of a coefficient of variation of nearly 40 percent, a twenty-car test fleet, consisting of duplicates of each of the ten recommended vehicles, would have been desirable. Unfortunately, funding was available for only fourteen vehicles in Phase I. For Phase II, the Fuels Selection Panel recommended testing five methanol-gasoline blends, although funding was available for only four blends. The CRC endorsed the desirability of testing the five fuel blends and directed the Vehicle Selection Panel to determine which vehicles should be deleted from the test fleet in order to stay within the available funding. The Panel selected vehicles that represented different design technologies, so that the alcohol-gasoline blends could be tested under as many differing conditions as possible. The Panel selected ten vehicles that represented principal engine configurations, including both Federal and California emission control systems, open- and closed-loop air fuel control systems, carburetted and fuel-injected engines, and two types of evaporative emission control systems. In addition, the Panel considered it important to have direct comparisons on the response of the open- and closed-loop systems to the alcohol-gasoline blends. The Panel, therefore, selected three car models (Horizon/Omni, Century, and Pinto) with otherwise identical engines for such comparisons. The closed-loop systems were calibrated for 1980 California emission standards, whereas the open-loop systems were calibrated for 1980 Federal standards. A comprehensive explanation of the statistical basis for the selection of the vehicles can be found in CRC Report No. 527[1] detailing the ethanol-gasoline blends (Phase I) portion of the study.

SECTION 2

VEHICLES

- None of the cars showed vapor lock on these fuels in tests at 100°F on a chassis dynamometer.

- No general trend of fuel economy versus alcohol content was found, because the three car models behaved differently; however, as the oxygen level of the fuel increased, more car models showed significant reductions in fuel economy compared with the base fuel. Because the fuel economy changes did not correspond to energy content changes, there were energy economy increases in two car models at high oxygen levels.

The results of this program and the analysis of variance are not sufficient to construct mathematical relationships between various vehicle performance factors and specific fuel properties or composition. Despite this limitation, and the fact that not all cars responded alike to the blending of alcohol in the fuel, the study showed that the presence of alcohol in gasoline affected all vehicle performance factors, except vapor lock and aldehydes; data from this program were insufficient to define the effects of alcohol on these performance factors.

Attempts were made to define mathematical relationships between vehicle performance factors and fuel properties by regression analysis. It was not possible, however, to isolate specific fuel properties affecting the performance parameters, because the experiment was not designed for this purpose. Consequently, another experimental program (statistically designed to isolate the effects of fuel variables) is needed to define the response of vehicle performance factors to fuel characteristics such as oxygen content and volatility, which this program strongly suggests are the two most influential on vehicle performance. Oxygen content affects stoichiometry and therefore affects vehicle operation; changes in volatility also affect vehicle operation.

The results of this study are qualitatively consistent with those of other investigations and of Phase I in which the effect of 10 percent ethanol in gasoline was investigated. Quantitative comparisons between Phase I and Phase II results are not appropriate, because oxygen content, hydrocarbon composition, vapor pressure, and distillation characteristics of the test fuels were not matched between the two phases.

1.3 RESULTS AND CONCLUSIONS

The main objective of the data analysis was to investigate, using analysis of variance, differences in vehicle performance among the six test fuels, and to determine whether the fuel effects were different for the different car models and/or car groups.

The results of the analysis of variance may be summarized as follows:

- All the alcohol-containing fuels, with the exception of Fuel 05B0, gave significantly lower FTP organic emissions than the base fuel.
- All the alcohol-containing fuels gave lower CO emissions than the base fuels. The blends with co-solvent gave lower CO emissions than those without co-solvent of equivalent oxygen content. Whether this effect is due to co-solvent (isobutanol) content, volatility, or other fuel factors cannot be determined from the data.
- Increasing fuel-alcohol content increased NO_x emissions. There appeared to be no significant effect of co-solvents on NO_x emissions.
- Methanol emissions were not significant with the base fuel but were significant with the alcohol fuels; however, the methanol concentrations in the exhaust emissions were proportionately much lower than they were in the original fuel.
- Because the variation in the aldehyde measurements was high, fuel effects on aldehyde emissions could not be identified.
- SHED organic emissions increased with increasing oxygen content. Increases in SHED organic emissions with the alcohol-containing fuels compared with the base fuel were statistically significant with the 5 and 8 weight percent oxygen fuels, but not with the 2 weight percent oxygen fuels. The effect of co-solvent was not statistically significant, nor was the difference in SHED organics between the 5 percent and the 8 percent oxygen fuels.
- Generally, as methanol content increased, the SHED methanol emissions also increased. Co-solvent effects on SHED methanol emissions were not statistically significant.
- Driveability demerits were significantly higher with all the alcohol fuels than with the base fuel. While there was no statistically significant difference between the 5 and 8 weight percent oxygen-content fuels, this group of fuels deteriorated driveability more than the 2 weight percent oxygen fuels. In all instances, co-solvent did not affect driveability demerits.

Code*	Gasoline Composition**	Methanol Content Vol %	Isobutanol Content Vol %	Oxygen Content Wt %
Base	BPH	0.0	0.0	0.0
02B0	PH	2.6	0.0	1.4
02B1	PH	3.4	1.2	2.1
05B0	PH	9.6	0.0	5.0
05B3	(PH)/2	8.8	3.0	5.3
08B2	PH	13.7	2.0	7.6

* The fuels are identified by the general fuel code OxBy, in which x is the nominal percent oxygen and y is the nominal percent isobutanol.

** BPH = Typical amounts of butanes, pentanes, and hexanes.
PH = Typical amounts of pentanes and hexanes, but essentially no butanes.
(PH)/2 = One-half of typical pentanes and hexanes, but essentially no butanes.

Ten of the fourteen 1980 model cars from the Phase I program were re-used in the Phase II program following renovation, re-inspection, and acceptance by CRC. These cars comprised three models by three automobile makers and two engine-emissions control groups for each model: open-loop calibrated for 1980 Federal emissions standards; and closed-loop calibrated for 1980 California emissions. Two of the three models were replicated.

Emissions data were obtained using the Federal Test Procedure (FTP) and Sealed Housing Evaporative Determination (SHED) tests. Fuel and energy economy were measured on the FTP (city test) and the Highway Fuel Economy Test (HFET). Combined fuel and energy economies were also calculated using the techniques developed by the Environmental Protection Agency (EPA). Intermediate-temperature driveability and vapor lock (one aspect of high-temperature driveability) were measured using published CRC research techniques. Organic emissions are based on an FID analyzer calibrated for hydrocarbon measurement. Unregulated emissions (exhaust aldehydes, and exhaust and evaporative methanol) were measured using techniques developed from a variety of literature sources. EPA's assistance was obtained in the implementation of these techniques. All tests were run at least in duplicate. In all, 144 emissions and economy tests, 120 driveability tests, and 120 vapor lock tests were conducted.

Section 1

SUMMARY

1.1 BACKGROUND

Recognizing a public interest in alcohol-gasoline blends such as gasohol, the US Congress in 1978 provided the US Department of Energy (DOE) Alternative Fuels Utilization Program with funds to test and evaluate alcohol-gasoline blends in commercial and government fleets. As a part of program implementation, DOE contracted with the Coordinating Research Council (CRC) to develop and conduct technical evaluations of these blends.

CRC, via its Light-Duty Vehicle Group on Alternative Automotive Fuels, developed a test program aimed at comparing the emissions, fuel economy, driveability, and vapor lock characteristics of both simple and volatility-adjusted ethanol-gasoline and methanol-gasoline blends with those of gasoline. The fuels were to be tested in 1980 model-year cars representing various emission-control technologies using test procedures accepted by the Government and Industry. Systems Control, Inc. (SCI) was chosen to do the testing. The results on the ethanol-gasoline blends (Phase I) were reported in CRC Report No. 527(1). The results on the methanol-gasoline blends (Phase II) are reported herein.

1.2 TEST PROGRAM

CRC specified six unleaded fuels for the methanol-gasoline phase of this program: a reference gasoline and five alcohol-containing fuels. The reference or base gasoline approximated average summer gasoline, and was very similar in inspections to the base gasoline used in the Phase I work. The alcohol-containing fuels were blended to give several oxygen contents with methanol alone and with isobutanol co-solvent accompanying the methanol, and to have similar volatility characteristics. The following table summarizes the contents of the fuels:

SECTION 1

SUMMARY

The matrix of twenty-four trial blends is shown in Table 3-1. Methanol content ranged from 0 to 15 volume percent. Isobutanol content ranged from 0 to 5 volume percent. The volatility adjustment of the gasoline fraction was achieved in three ways as follows:

- Butane removal to less than 1.0 volume percent C_4 hydrocarbons by GC;
- Butane removal to less than 1.0 volume percent C_4 hydrocarbons plus 50 percent removal of C_5 and C_6 hydrocarbons relative to base gasoline; and
- Butane removal to 50 percent of the C_4 hydrocarbon content of base gasoline plus 25 percent removal of C_5 and C_6 hydrocarbons relative to base gasoline.

Since the scope of this project allowed only a limited number of test fuels for vehicle performance testing, the trial blends matrix was used to suggest test fuels which would have acceptable water tolerance and volatility characteristics for use in the current distribution system. Some results of the trial blends testing are described below.

Water tolerance may show some variation across the range of base stock compositions in the trial blends, but much more dramatic changes in water tolerance occur with co-solvent (isobutanol) addition, as shown in Table 3-2. Increasing water tolerance also results from increasing alcohol dosage; however, increasing methanol content is much less effective in improving water tolerance than increasing the total dosage of a 3:1 methanol:isobutanol mixture. This is illustrated in Figure 3-1 for one base stock. Results are parallel in the other base fuels.

Volatility parameters are also affected by alcohol addition. The increases in RVP from adding methanol (2.1 to 3.3 psi) are usually reduced by addition of co-solvent. Table 3-3 suggests, however, that compositional sensitivity among the trial blends may be more important in RVP effects than in water tolerance. Similar co-solvent effects also may be observed in other traditional measures of front end volatility. Table 3-4 shows differences in V/L = 20 and V/L = 30 temperatures for given methanol dosages with and without co-solvent. For this measure of volatility, co-solvent consistently reduces front end volatility.

The hydrocarbon composition of the base fuels is shown in Table 3-5. Data furnished by the fuel supplier are tabulated in Appendix C. During analysis of the data, it was observed that MB2 base fuel was deficient in pentane content relative to the intended level. The available data were reviewed with the decision to specify five methanol-gasoline test fuel blends contingent upon preparation and approval of hand blends of those fuels. The five blends were selected to bracket methanol concentration expected to have market use potential.

TABLE 3-1. METHANOL-GASOLINE BLENDS FOR LABORATORY TESTING

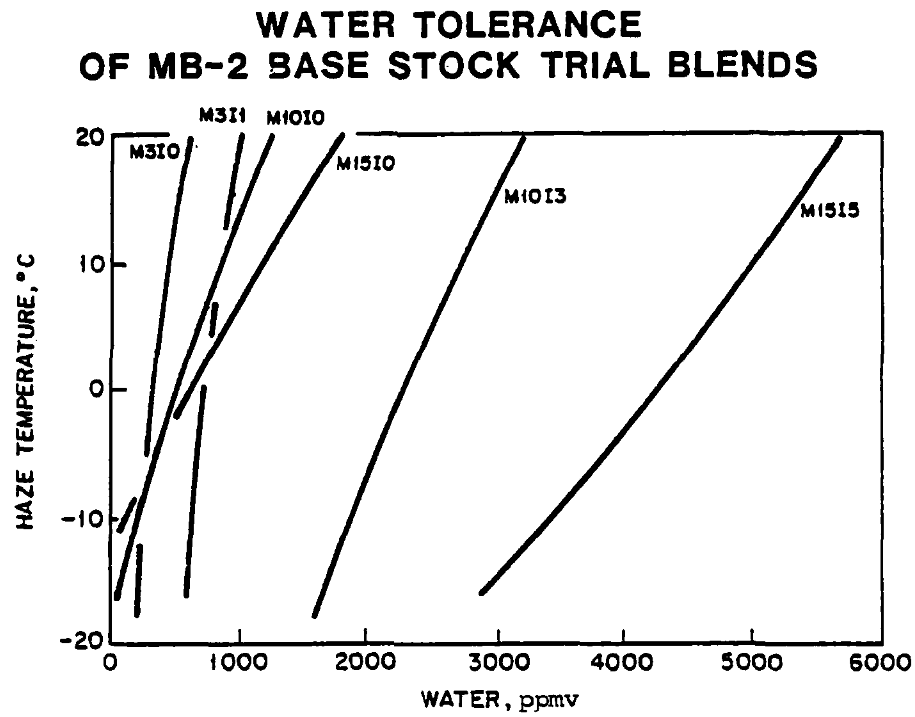
COMPONENT	BLEND COMPOSITION, VOL. %						
Methanol	0	3	3	10	10	15	15
Isobutanol	0	0	1	0	3.3	0	5
Gasoline	100	97	96	90	86.7	85	80

GASOLINE FRACTION: DESIGNATION	HYDROCARBON COMPOSITION							
MB1	Base gasoline	X	X	X	X	X	X	X
MB2	Base modified by butane removal to RVP of 10% methanol blend = ±0.2 lb of base RVP or to less than 1.0 Vol. % C_4 by GC	X	X	X	X	X	X	X
MB3	Base modified by removal of C_4 to less than 1.0 Vol. % by GC and 50% removal of C_5 and C_6	X	X	X	X	X	X	X
MB4	Base modified by 50% removal of C_4 and 25% removal of C_5 and C_6	X			X	X		

TABLE 3-2. WATER TOLERANCE OF TRIAL BLENDS

Base		MB1	MB2	MB3	MB4
Alcohol Dosage, vol %					
MEOH	IBA				
			Water Tolerance at -15°C, vol % H_2O		
3	0	0.05	0.02	0.05	
3	1	0.11	0.06	0.06	
10	0		0.01	0.02	0.01
10	3.3	0.15	0.17	0.16	0.18
15	0				
15	5	0.25	0.30	0.30	
			Water Tolerance at 5°C, vol % H_2O		
3	0	0.07	0.04	0.05	
3	1	0.14	0.08	0.07	
10	0	0.06	0.07	0.08	0.08
10	3.3	0.26	0.25	0.26	0.27
15	0	0.02	0.09	0.09	
15	5	0.41	0.46	0.56	
			Water Tolerance at 20°C, vol % H_2O		
3	0	0.08	0.06	0.06	
3	1	0.16	0.10	0.09	
10	0	0.11	0.12	0.13	0.13
10	3.3	0.34	0.32	0.33	0.33
15	0	0.11	0.18	0.19	
15	5	0.53	0.57	0.56	

FIGURE 3-1


WATER TOLERANCE
OF MB-2 BASE STOCK TRIAL BLENDS
M3I1
M10I0
M3I0
M15I0
M10I3
M15I5
HAZE TEMPERATURE, °C
20
10
0
-10
-20
0
1000
2000
3000
4000
5000
6000
WATER, ppmv

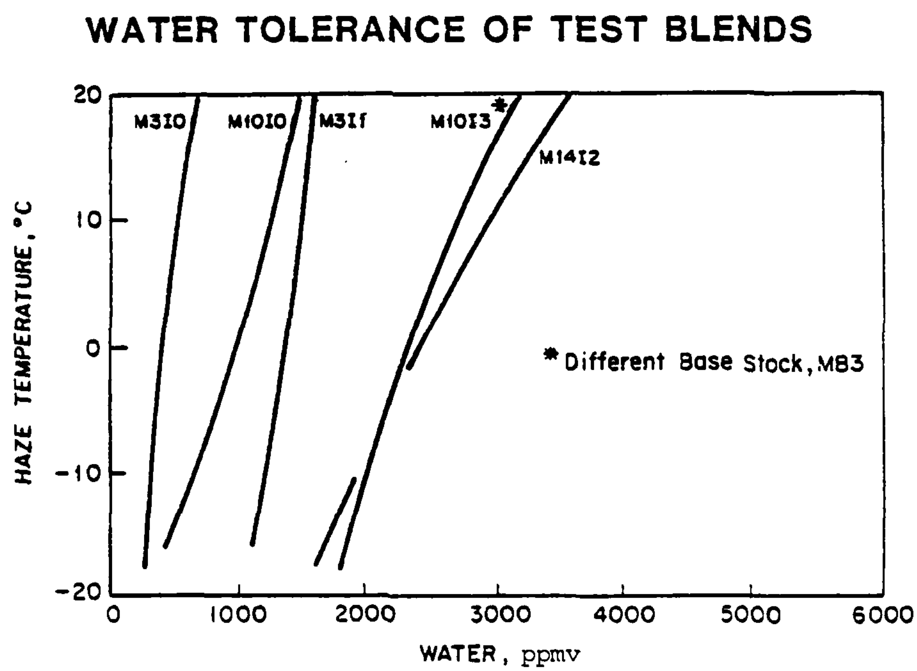

WATER TOLERANCE OF TEST BLENDS
M3I0
M10I0
M3I1
M10I3*
M14I2
* Different Base Stock, MB3
HAZE TEMPERATURE, °C
20
10
0
-10
-20
0
1000
2000
3000
4000
5000
6000
WATER, ppmv

TABLE 3-3. RVP'S FOR TRIAL BLENDS

Base		MB1	MB2	MB3	MB4
Base RVP		9.7	5.2	4.8	7.4
Alcohol Dosage, vol %			△ RVP from Base		
MEOH	IBA				
3	0	2.3	2.7	2.1	
3	1	1.5	1.8	2.5	
10	0	2.8	2.6	2.5	3.3
10	3.3	2.7	2.5	2.2	2.9
15	0	2.7	2.6	2.5	
15	5	2.0	2.3	2.5	

TABLE 3-4. CHANGES IN VAPOR/LIQUID RATIOS BETWEEN METHANOL AND METHANOL/ISOBUTANOL BLENDS

Methanol Dosage, vol %	Difference ($T_{V/L=20}$ MeOH/IBA - $T_{V/L=20}$ MeOH), °C			
Base Stock	MB-1	MB-2	MB-3	MB-4
3	+2.4	+3.0	+1.8	---
10	+6.8	+3.8	+3.1	+6.1
15	+5.6	+3.9	+3.8	---

Methanol Dosage, vol %	Difference ($T_{V/L=30}$ MeOH/IBA - $T_{V/L=30}$ MeOH), °C			
Base Stock	MB-1	MB-2	MB-3	MB-4
3	+3.2	+2.8	+1.5	---
10	+7.2	+4.5	+3.1	+6.6
15	+7.6	+3.9	+4.2	---

MeOH/IBA = 3/1 in all cases

TABLE 3-5. HYDROCARBON COMPOSITION OF FUELS FOR TRIAL BLENDS*

COMPONENT	BASE FUEL DESIGNATION			
	MB1	MB2	MB3	MB4
n-Butane	6.9	0.0	0.0	3.4
Isopentane	8.8	9.5	4.4	6.7
Cyclopentane	6.9	7.4	3.5	5.2
Mixed Xylenes	8.8	9.5	10.5	9.6
Nonyl Aromatics	5.9	6.3	7.0	6.5
Reformate	14.7	15.8	17.5	16.1
Alkylate	24.5	26.3	29.1	26.7
Cat Cracked Gasoline	23.5	25.2	28.0	25.7
Total	100.0	100.0	100.0	99.9
Butanes by GC	6.20	0.47	0.58	**
Pentanes by GC	15.16	12.84	8.16	**

* Volume Percent for blending components; weight percent for GC analysis

**Not determined

3.2 TEST FUEL SPECIFICATIONS

Table 3-6 shows the fuels which were specified for testing. The fuels are identified by the general fuel code OxBy, in which x is the nominal percent oxygen and y is the nominal percent isobutanol. The parameters of primary concern were oxygen content, volatility, and water tolerance. Alcohol content, co-solvent content, and hydrocarbon composition were the blending variables. The fuel specification provided the following:

- oxygen content and resulting fuel stoichiometry varied from the 2.0 weight percent level permitted by EPA for other alcohols up to the 8 weight percent levels being field tested in other countries;

- three levels of oxygen content were provided with the same (reduced) base gasoline volatility (02B0/02B1, 05B0, and 08B2);

- volatility at the same oxygen level was varied considerably through base fuel hydrocarbon composition change and/or addition of isobutanol (02B0 versus 02B1 and 05B0 versus 05B3); and

- methanol without co-solvent was tested at the same volume percent alcohol as the Phase I ethanol blends.

3.3 BLENDING PROCEDURES

The base gasoline was blended using various refinery stocks used for typical gasoline. The Phase II gasoline components were from different batches than the Phase I components. However, the Phase II base gasoline batch volatility characteristics agreed within test repeatability of the Phase I base gasoline volatility characteristics. Sufficient component stocks were set aside for blending the other Phase II fuels.

The methanol and isobutanol used for blending the Phase II fuels were purchased from various vendors who certified their alcohols to meet the specifications shown below:

PROPERTY	METHANOL	ISOBUTANOL
Purity, min.	99.85 wt. %	99.50 wt. %
Water content, max.	0.10 wt. %	0.10 wt. %
Acidity (as acetic acid), max.	0.003 wt. %	0.003 wt. %

TABLE 3-6. BLENDING TARGETS FOR PHASE II METHANOL-GASOLINE FUELS

Fuel Code	Base Fuel	C_4 Vol %	C_5 Vol %	Methanol Vol %	Isobutanol Vol %	Oxygen wt %
Base	MB1	7*	16*	0	0	0
02B0	MB2	<1	16	3.8	0	2.0
02B1	MB2	<1	16	3.3	1.1	2.0
05B0	MB2	<1	15	10.0	0	5.2
05B3	MB3	<1	8	8.8	2.9	5.2
08B2	MB2	<1	14	14.0	2.0	7.9

* Volume percent of C_4 and C_5 hydrocarbons required to meet volatility specifications for base gasoline (MB1) as shown below:

Micro Vapor Pressure, psi (D 2551)	9.5 ± 1.0
Research Octane Number (D 2699)	91 min.
Motor Octane Number (D 2700)	82 min.
$\frac{R + M}{2}$	87-89
D 86 Distillation	
10% Evaporated	115-130°F
30%	160-180°F
50%	210-230°F
70%	255-280°F
90%	315-345°F
FBP	<425°F

All blends were prepared from component stocks by adding or withholding the specified component. Four of the methanol-gasoline blends were prepared without adding butane as a blending component (02B0, 02B1, 05B0, and 08B2). These fuels were reduced in volatility compared with the fuels which would have existed if butane had been added in the same proportion as for base gasoline. One methanol-gasoline blend (05B3) was prepared by adding no butane and half the pentanes and hexanes relative to base gasoline MB1.

3.4 FUEL STORAGE

After blending, fuels were drummed and stored until shipment to SCI. The drummed fuels were stored outdoors, under shade, on their sides, with the bungs under the fluid level. The drums were stored in tiers, four drums high. At no time was drum leakage observed, although some drums were distended. All drums showing deformation were opened under chilled conditions and the fuels were redrummed in stronger drums.

Fuels were shipped to SCI in refrigerated vans to avoid the high temperatures encountered in closed vans on desert highways during summer. At SCI, fuels were stored in a specially constructed refrigerated building that could hold up to twenty-five drums. The refrigerated building provided equilibration at 55°F, prior to moving the drums inside the laboratory for testing. Fuels were dispensed from the drums into test vehicles from a refrigerated fuel-dispensing shed located in the soak area of the test laboratory. Once opened in the dispensing shed, the drums were kept under pressure, using compressed nitrogen, to minimize loss of light ends.

3.5 INSPECTION RESULTS

To provide accurate inspection data on the test fuels, samples were carefully drawn into chilled containers from the drums kept in cold storage at SCI. They were sent to five participating laboratories for round-robin testing. Samples were also sent to Phoenix Laboratories in Chicago for energy content, gravity, and carbon/hydrogen contents. Only the energy contents from Phoenix were used.

When multiple data were available, an analysis was made to define outliers. Averages were obtained after deleting outliers. Table 3-7 presents a summary of the average inspections. All the data were from the round-robin tests except for the energy contents, and for temperature for a vapor/liquid ratio of 20, butanes content, pentanes content, water tolerance, and octane numbers. The latter data are from the fuel supplier. Oxygen contents were calculated from the measured alcohol contents using the theoretical oxygen content of each alcohol.

TABLE 3-7. TEST FUEL INSPECTIONS

INSPECTION	BASE	02B0	02B1	05B0	05B3	08B2
Methanol, Vol % (GC)	0.0	2.6	3.4	9.6	8.8	13.7
Isobutanol, Vol % (GC)	0.0	0.0	1.2	0.0	3.0	2.0
RVP, psi	9.2	8.5	8.1	8.6	7.7	8.3
API Gravity, °API (D 287)	59.4	54.2	54.5	54.1	54.7	53.6
Specific Gravity	0.741	0.762	0.761	0.762	0.760	0.764
Distillation (D 86), °F at % Evaporated						
IBP	88	106	107	109	113	109
10	124	120	124	123	128	125
30	175	188	186	133	155	137
50	224	232	225	223	219	209
70	255	266	260	257	253	253
90	318	337	324	322	326	317
EP	401	424	406	400	404	401
% Evaporated at 158°F	24	22	23	35	31	44
Temperature for V/L = 20, °F (D 2533 Modified)	135	128	130	124	131	125
Net Heating Value, Btu/Gallon x 10^{-3} (D 240 Modified)	114.9	115.4	114.1	110.7	110.4	107.7
Butanes, Wt % (GC)	6.2	0.3	0.5	0.6	0.6	0.4
Pentanes, Wt % (GC)	15.2	12.5	11.3	11.4	7.6	9.7
Carbon, Wt %	86.4	85.6	85.0	82.2	81.8	80.1
Hydrogen, Wt %	13.4	12.8	13.0	12.7	13.1	12.9
Oxygen, Wt %	0.0	1.4	2.1	5.0	5.3	7.6
Water Tolerance Vol % at Temp., °C						
-15	-	0.029	0.108	0.045	0.188	0.165
5	-	0.054	0.137	0.102	0.253	0.274
20	-	0.073	0.159	0.145	0.320	0.355
Research ON (D 2699)	97.4	98.2	99.0	100.2	100.0	100.6
Motor ON (D 2700)	86.6	86.8	86.8	86.8	86.3	87.0
(RON/MON)/2	92.0	92.6	92.8	93.4	93.2	93.7

To determine alcohol contents, gas chromatographs or mass spectrometers were used. Since there is no standard method, each participant used a different technique. The GC method used by Amoco is described in the Journal of Chromatographic Science[2].

The following two alternate methods were used to measure RVP because water is present in the standard method: the micromethod (ASTM D 2551); and an automatic tester distributed by Southwest Research Institute. The temperature for a vapor/liquid ratio of 20 was measured using a modified version of ASTM D 2533; mercury was used in place of glycerine.

Carbon and hydrogen contents were measured using combustion methods in which exhaust carbon dioxide and water contents are determined. The method used by Amoco is presented in Reference 3.

Water tolerance was determined by adding measured amounts of water to the fuel samples, and then chilling them at a constant rate in a Wescan automatic cloud point apparatus until haze appeared. The samples were protected from exposure to the atmosphere during the tests. For each sample, percent water tolerance was determined for the three temperatures (-15°C, 5°C, and 20°C) by plotting the total water content versus the measured haze temperature.

Detailed fuel properties from both the fuel supplier data and from the CRC round-robin analysis are shown in Appendix C. All specifications were met, except that the (R+M)/2 average octane rating of the base fuel was higher than the original specification; i.e., the fuel is typical of premium rather than regular grade gasoline.

3.6 CARBON-BALANCE FUEL ECONOMY

The parameters used to calculate carbon-balance fuel economy are presented in Table 3-8. Values for C, H, and O mass fractions agreed upon by the Data Analysis Panel after reviewing the available data, and the other fuel properties used for calculation purposes, are shown in the table. Energy economy, in miles-per-million Btu, was computed from fuel economy by dividing miles-per-gallon by the lower heating values, in Btu's-per-gallon, present in the table. It should be noted that the data in Table 3-8 are different from those shown in Table 3-7, which were obtained after the performance testing was completed.

Carbon-balance fuel economy was computed from the standard equation:

$$MPG = \frac{F \times D}{F \times E_{HC} + 0.429 \times E_{CO} + 0.273 \times E_{CO_2}}$$

where:

MPG = fuel economy in miles per gallon
D = fuel density in grams per gallon
E = exhaust emissions in grams per gallon
F = carbon mass fraction of the fuel

TABLE 3-8. CARBON-BALANCE FUEL ECONOMY PARAMETERS FOR PHASE II

	BASE	02B0	02B1	05B0	05B3	08B2
Mass Fraction: Carbon (F)	0.8646	0.8638	0.8478	0.8190	0.8180	0.8018
Hydrogen	0.1309	0.1256	0.1282	0.1302	0.1318	0.1278
Oxygen	0.0045	0.0106	0.0240	0.0508	0.0502	0.0704
Density, grams/gallon, (D)	2801	2877	2877	2873	2881	2877
Grams Carbon/Gallon, (F x D)	2422	2485	2439	2353	2357	2307
Net Heating Value, thousand Btu/gallon	114.9	115.4	114.1	110.7	110.4	107.7

SECTION 4

TEST METHODOLOGY

Sums of squares for the two nested factors could be calculated directly or by summing appropriate sums of squares involving the main effects and interactions involving cars; e.g.,

$$SSC(GM) = 12 \sum_{j=1}^{2} \sum_{k=1}^{3} \sum_{\ell=1}^{n_{jk}} (\bar{y}_{.jk\ell.} - \bar{y}_{.jk..})^2$$

$$= SSC + SSCG + SSCM + SSCGM$$

The expected mean squares in the analysis of variance table indicate the influence of the various model terms on the main effects and interactions. The ϕ-functions are multiple of the sums of squares of the main effects or interactions whose factors are shown in parenthesis; e.g.,

$$\phi_1(F) = 4 \sum_{i=1}^{6} F_i^2$$

(using the usual convention that $\Sigma F_i = 0$).

The experimental design of this four-factor experiment consisted of 128 tests in which measurements were taken on seven emissions variates and eight economy and driveability variates. The four factors whose effect on these fifteen variates were to be analyzed were: fuel (6), engine group (2), vehicle model (3), and replicate cars (1 or 2 depending upon the model). The model factor identification and levels were:

Fuel (i)	Group (j)	Model (k)
Base (1)	Open-Loop (1)	O
02B1 (2)	Closed-Loop (2)	C
02B0 (3)		P
05B3 (4)		
05B0 (5)		
08B2 (6)		

	Car (ℓ)	
Model	Open-Loop	Closed-Loop
O	04-1 (1)	C4-1 (1)
	04-2 (2)	C4-2 (2)
C	06-1 (1)	C6-1 (2)
P	04-3 (1)	C4-3 (1)
	04-4 (1)	C4-4 (1)

The following is an analysis of variance table that summarizes the model used to analyze the Phase II data:

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	Expected Mean Squares
Fuels (F)	5	SSF	MSF	$\sigma^2 + 2\sigma^2_{FC} + \phi_1(F)$
Groups (G)	1	SSG	MSG	$\sigma^2 + 12\sigma^2_C + \phi_2(G)$
Models (M)	2	SSM	MSM	$\sigma^2 + 12\sigma^2_C + \phi_3(M)$
FxG	5	SSFG	MSFG	$\sigma^2 + 2\sigma^2_{FC} + \phi_4(FG)$
FxM	10	SSFM	MSFM	$\sigma^2 + 2\sigma^2_{FC} + \phi_5(FM)$
GxM	2	SSGM	MSGM	$\sigma^2 + 12\sigma^2_C + \phi_6(GM)$
FxGxM	10	SSFGM	MSFGM	$\sigma^2 + 2\sigma^2_{FC} + \phi_7(FGM)$
Cars (C) [GxM]*	4	SSC[GM][1]	MSC[GM]	$\sigma^2 + 12\sigma^2_C$
FxC [GxM]	20	SSFC[GM][2]	MSFC[GM]	$\sigma^2 + 2\sigma^2_{FC}$
Error (ε)	60	SSε	MSε	σ^2

* Bracket indicates nesting.

TOTAL (adj) 119 TSS (adj)

[1] SSC[GM] = SSC + SSCG + SSCM + SSCGM

[2] SSFC[GM] = SSFC + SSFCG + SSFCM + SSFCGM

Standard formulae for calculating the sums of squares of the main effects and interactions where appropriate; e.g.,

$$SSF = 20 \sum_{i=1}^{6} (\bar{y}_{i\ldots\ldots} - \bar{y}_{\ldots\ldots\ldots})^2$$

and

$$SSFG = 10 \sum_{i=1}^{6} \sum_{i=1}^{2} (\bar{y}_{ij\ldots} - \bar{y}_{i\ldots\ldots} - \bar{y}_{.j\ldots} + \bar{y}_{\ldots\ldots\ldots})^2$$

$$= 10 \sum_{i=1}^{6} \sum_{i=1}^{2} \bar{y}^2_{ij\ldots} - SSF - SSG - SS(\mu)$$

where: $SS(\mu) = n\bar{y}^2_{\ldots\ldots}$

$$y_{ijk\ell m} = \mu + F_i + G_j + (FG)_{ij} + M_k + (FM)_{ik} + (GM)_{jk} + (FGM)_{ijk} + C_{\ell(jk)} + (FC)_{i\ell(jk)} + \varepsilon_{ijk\ell m}$$

where:

y = vehicle performance parameter (henceforth, referred to as a variate

μ = overall (constant) mean effect

F_i = fixed effect due to i^{th} fuel ($i = 1,2,\ldots 6$)

G_j = fixed effect due to j^{th} engine group ($j = 1,2$), (open, closed-loop)

M_k = fixed effect due to k^{th} vehicle model ($k = 1,2,3$), (Model O, Model P, Model C)

$(FG)_{ij}, (FM)_{ik}, (GM)_{jk}, (FGM)_{ijk}$ are fixed interaction effects,

$C_{\ell(jk)}$ = random effect of ℓ^{th} car of j^{th} group and k^{th} model ($\ell = 1, n_{jk}$), ($n_{jk} = 1$ if $k = 2$ [for each j], $n_{jk} = 2$ if $k = 1,3$ [for each j])

$(FC)_{i\ell(jk)}$ = random interaction effect

$\varepsilon_{ijk\ell m}$ = random error of the m^{th} replicate ($m = 1,2$)

All random components in this model were assumed to be mutually independent with:

$C_{\ell(jk)} \sim N(0, \sigma_C^2)$, $(FC)_{i\ell(jk)} \sim N(0 \sigma_{FC}^2)$ for fixed i (i.e., for a specific fuel), and $\varepsilon_{ijk\ell m} \sim N(0, \sigma^2)$

Organic emissions (ORG) represent the total response of the FID analyzer, reported according to the method prescribed for HC emissions in the CFR[6]. No corrections were applied to the data to account for the presence of methanol or isobutanol. Hydrocarbon emissions (HC) represent the FID response after subtracting out aldehyde and methanol.

Two measures of fuel economy, carbon-balance and volumetric, were obtained for all vehicles. Analysis of the carbon-balance and volumetric fuel economy data showed higher values for carbon-balance measurements. Analysis of the scatter within each set of measurements showed that neither measure of fuel economy was superior; so for these vehicles, the average of the two measures was used for the analysis of fuel economy.

Driveability and vapor lock data were determined for each test as described in Appendix E. Total weighted demerits for driveability and percent increase in critical acceleration time for each vapor lock test were then entered into the computer to simplify further data-handling.

A total of 144 emissions tests were performed, of which 128 met the test data audit criteria discussed in Appendix F. Test data for individual vehicles are tabulated in Appendix B.

5.2 STATISTICAL ANALYSIS METHODOLOGY

The objective of the analysis was to investigate, using analysis of variance, differences in vehicle performance for the six test fuels, and to determine whether the fuel effects were different for the different car models and/or car groups.

The fuels were not designed to allow independent evaluation of fuel factors such as alcohol content, oxygen content, and volatility; however, several attempts were made to perform regression analysis on the data to determine if the effects of the fuel variables could be isolated. Because of the high correlation among the fuel properties, regression analyses using many different combinations of the fuel properties gave equally good correlation with vehicle performance, where several of the combinations had no physical significance; therefore, no regression analyses are presented.

Analyses of variance were performed by Gunstat Research and Analysis, with a model that differed somewhat from the model used in Phase I. The linear model selected for the analysis of these tests was:

Section 5

RESULTS

This section discusses the test results obtained from the program. Separate subsections are devoted to the following:

- Treatment of Test Data
- Statistical Analysis Methodology
- Results of Statistical Analysis
- Test Results

  Emissions

  Driveability and Vapor Lock

  Fuel (mpg) and Energy (miles/million Btu [mi x MBtu]) Economy

5.1 TREATMENT OF TEST DATA

Raw data from each test were entered via a terminal into SCI's PDP 11/35 computer system for reduction and analysis. Calculations were based on formulas shown in the Code of Federal Regulations (CFR)[6]; however, the calculations were modified to reflect the effect of modified fuel composition on carbon-balance fuel economy, and to permit mass emission calculations of aldehyde and methanol emissions.

SECTION 5

RESULTS

4.5 QUALITY ASSURANCE

This section describes measures taken to ensure that the test results were accurate and precise. The following topics are addressed:

- Laboratory Checkout
- Periodic Calibrations
- Test Data Audit

4.5.1 Laboratory Checkout

After completion of all facility modifications required for Phase I testing, an extensive checkout of all equipment, instruments, and procedures was undertaken before testing was allowed to begin. Checkout included developing calibrations for dynamometer coastdowns, instruments, and CVS. The data developed were reviewed by SCI Quality Control Personnel to ensure compliance with requirements.

As a final part of checkout, a series of demonstration tests were performed to show test repeatability and the ability to recover known quantities of formaldehyde, ethanol, and methanol injected into the sampling system. Results of these tests are shown in Appendix F, Table F-2.

Demonstration tests were observed by members of the Analytical Procedures Panel of the Alternative Automotive Fuels Group on two different occasions. Recommendations were made to SCI for improving recovery rates and repeatability of aldehyde and alcohol measurements. These recommendations were adopted and resulted in improved measurement precision. No additional modifications were made before beginning the Phase II work.

4.5.2 Periodic Calibrations

Periodic calibration and performance checks were performed throughout the program. Additional unscheduled calibrations and performance checks were also performed after unscheduled instrument maintenance activities, or if unreasonable calibration or emission data were obtained. A sumary of these calibration checks is presented in Appendix F.

4.5.3 Test Data Audit

Calibration and test data were recorded on data sheets and strip charts. The data for each test were compiled into a data packet by test personnel and submitted to SCI Quality Control (QC). Data were audited, approved, and processed by QC in accordance with procedures used on emission test programs. The criteria are generally based on requirements contained in the CFR, and specifically reflected procedures required of EPA contract laboratories. Where special procedures were involved, i.e., performance testing and alcohol/aldehyde determinations, acceptance criteria were established by the Analytical Procedures Panel of the CRC Alternative Automotive Fuels Group. Data audit criteria are discussed in more detail in Appendix F.

4.2.4 Highway Fuel Economy Test Procedure (HFET)

Following the hot soak evaporative emission sequence, the test vehicle was again placed on the dynamometer. In order to ensure that the vehicle was warmed up for the HFET, a preconditioning cycle was performed which consisted of a 3.1-minute, 50-mph cruise to check and reset the horsepower, followed by one HFET. Within one minute of the preconditioning, the 765-second, 10.2-mile HFET cycle began, during which an exhaust sample was collected for analysis of HC, CO, CO_2, NO_x, and fuel economy by carbon balance procedures. No aldehyde or alcohol samples were taken during the highway test. Volumetric fuel economy was also recorded.

4.3 COLD-START DRIVEABILITY TESTING

The cold-start driveability procedure consisted of a cold start (after an overnight soak), followed by 3.6 miles of driving through various maneuvers such as light-throttle accelerations, cruises, detent accelerations, full-throttle accelerations, crowd accelerations, and idles. The procedure was based on a road test procedure[8] used by CRC to evaluate the effect of changes in fuel volatility on vehicle driveability. Demerits were assigned for specific abnormal performance characteristics. Demerits were weighted by the type and severity of the malfunction. As driveability deteriorated, the number of total weighted demerits increased. The cold-start driveability test was performed between 50°F to 70°F on a road route originating at SCI's laboratory. Soak temperatures, however, were less than 50°F. Tests were run in duplicate on each car/fuel combination, with some triplicate tests in cases where the duplicates did not repeat well. The average total weighted demerits were reported as the measure of driveability for each car/fuel combination. Tests were performed by trained raters and are described more fully in Appendix E.

4.4 VAPOR LOCK TESTING

The vapor lock test sequence consisted of three wide-open throttle (WOT) accelerations from 15 mph to 70 mph. Acceleration times following an idle and engine-off soak were compared with the pre-soak acceleration time, and a percent increase calculated. An increase in acceleration time was used as the measure of vapor lock. The procedure was performed on a chassis dynamometer, but was based on a road test procedure[9] used by CRC to evaluate the vapor-locking tendency of fuels. The test sequence was performed at 100°F on all vehicles. The most critical engine soak (idle or engine-off) and speed range (15-50, 15-60, or 15-70 mph) were determined for each test, and the percent increase in acceleration time relative to the baseline acceleration was determined. Test procedures are described more fully in Appendix E.

Vehicles were prepared for tests in a manner which minimized vehicle variability as much as possible. Fuel was drained through fittings placed in the bottom of each tank. This ensured that as much fuel as possible was actually drained from the tank. Fuel was stored under refrigeration and dispensed directly from drums into the vehicle. A volumetric metering system was used to automatically and accurately dispense fuels. The fuel tank was left open during draining and filling to ensure that the canister was not accidentally charged or purged during fueling.

4.2.3 Federal Test Procedure (FTP) With Evaporative (SHED) Emissions

Following the 12- to 36-hour soak period, the vehicle fuel tank was drained and refilled with chilled test fuel (55°F) to 40 percent of the fuel tank volume to the nearest tenth-gallon. The vehicle was then transferred to the SHED and its windows and luggage compartment were opened. The temperature sensor and infrared heat source were connected to the temperature recorder and heat controller, respectively.

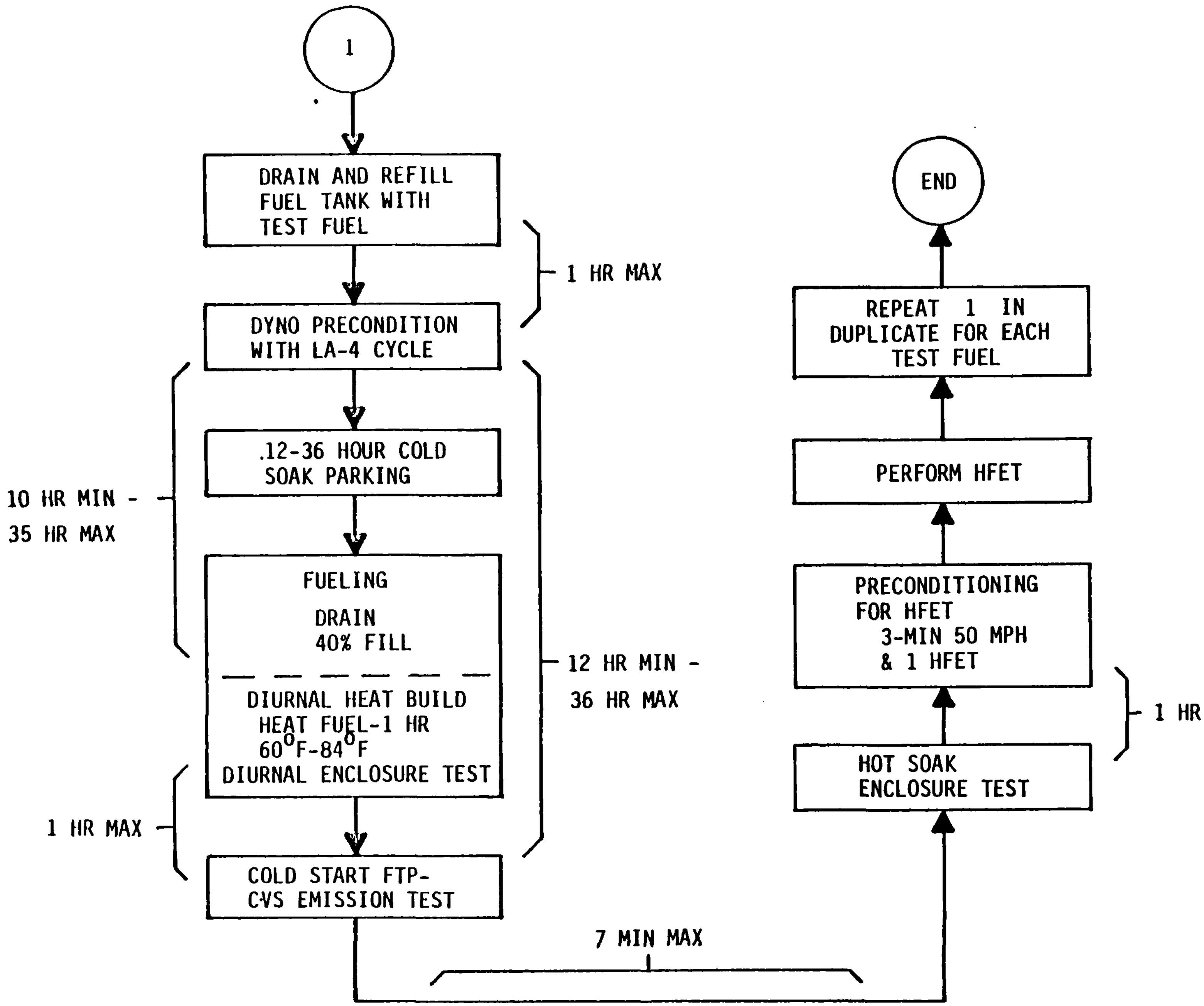
When the temperature of the fuel reached 60°F, the enclosure was sealed and diurnal heat-build began. Heat-build was defined as a temperature rise of 24° ± 1°F over a 60 ± 2-minute test period. During this period, total hydrocarbon emission levels were continuously recorded. A bag sample used for chromatographic analysis of ethanol and methanol was collected during the first minute and the last minute of each test.

When the diurnal portion of the SHED was complete, the test vehicle was placed on the dynamometer and the cold-start FTP was performed. During the FTP, exhaust samples were collected in sample bags for analysis of HC, CO, CO_2, NO_x, and fuel economy (carbon balance). Samples were also collected for ethanol and methanol response by gas chromatographic procedures, and aliphatic aldehydes were collected and analyzed using the MBTH method. Fluidyne fuel economy measurements (volumetric) were also recorded.

Within seven minutes of the end of the hot portion of the FTP, the test vehicle was placed back in the SHED and the one-hour hot soak was performed. Evaporative emission samples were analyzed as in the diurnal portion of the evaporative test.

At the end of each phase of evaporative emission tests, the sources of evaporative emissions were identified using a probe connected to the FID hydrocarbon detector. Using this technique, hydrocarbon and alcohol emission sources (fuel cap, quick-connects, etc.) were identified and possible fuel system leaks ruled out, so that emissions performance was clearly due to fuel effects.

FIGURE 4-1. EMISSION TEST SEQUENCE



4.2 EMISSION TESTING

Emission tests were conducted at least in duplicate on each test vehicle for each of the six test fuels (base gasoline plus five methanol-gasoline blends). These tests were the 1978 FTP-CVS tests with evaporative emissions (SHED) and the Highway Fuel Economy Test. These tests were performed according to the Federal Test Procedure (FTP) defined in the Code of Federal Regulations (CFR), Title 40, Part 86, Subparts A and B for 1980 model-year vehicles[6], except that aldehydes (exhaust) and methanol (exhaust and SHED) emissions and Fluidyne volumetric fuel economy were also measured. The following paragraphs describe the emission test procedures used. Detailed test procedures are found in Appendix E. Figure 4-1 illustrates the test sequence.

4.2.1 Carbon Canister Preconditioning

The carbon canisters were purged to a stable weight by applying vacuum to all ports normally connected to either engine vacuum sources or fuel vapor sources. The canister was heated to approximately 120°F to promote purging. After purging, the canister was attached to a container of the test fuel with which the vehicle was to be tested next. The outlet of the canister was connected to a 250-gram control canister. Fuel vapors were passed through the vehicle canister, until approximately 2 grams of vapor were collected on the control canister. The vehicle canister weight was recorded prior to vacuum purge, prior to charging, and after charging.

The carbon canisters were preconditioned in order to reduce variability in evaporative emissions caused by adsorption of alcohols and hydrocarbons on the activated carbon. Without preconditioning, it was expected that the canister system would show a "memory" from one fuel to the next.[7]

4.2.2 Vehicle Preconditioning

After preconditioning the canister and prior to the FTP, the vehicle fuel tank was drained and refilled to 40 percent of tank volume with one of the test fuels. After the vehicle's fuel tank was refilled with test fuel and the canister was reinstalled, the vehicle was preconditioned by driving it on the dynamometer while following the LA-4 driving schedule. Following the dynamometer driving, the vehicle was placed in the soak area and parked for a 12- to 36-hour soak period.

(Teflon), a nonadsorptive highly inert support which minimized tailing of the alcohol peaks. The SF 96 was a nonpolar liquid phase which separated according to boiling point. Those compounds with boiling points greater than ethanol (C_7 hydrocarbons and above, in general) were backflushed to vent, while methanol, ethanol, and organics with boiling points below ethanol eluted to the downstream selective column. The selective column was packed with Carbowax 1540 coated on Chromosorb T. Carbowax 1540 is a polyethylene glycol, a polar liquid phase with selectivity for polar compounds such as alcohols and other oxygenated organics. The Carbowax 1540 had little affinity or selectivity for the C_6 and below hydrocarbons which passed through the stripper column. They eluted quickly as a composite peak early on the chromatogram. Methanol and ethanol were retained and eluted as separate peaks.

During the development phase, the column system was carefully tested to ensure that methanol and ethanol were positively separated from the most probable interfering compounds. The instrument was tested on pure methanol and ethanol. Hexanes and heptane were added to ensure that the proper boiling point cuts were being made on the stripper column. Benzene was verified as not interfering. Although pure hydrocarbon interferences were eliminated with a high degree of certainty, there was the possibility of interference of low molecular weight oxygenated organics. Although it was unlikely that they would elute exactly coincident with the methanol or ethanol peaks on a Carbowax column of this length, auto exhaust from unleaded gasoline was run and found to have trace levels of methanol and ethanol present. The GC was calibrated using precision (±1%) compressed calibration gases (methanol and ethanol). The calibration gases were run through the GC and the instrument response recorded. The bag samples were then run through the GC and their instrument responses recorded. The concentration of ethanol and methanol was determined from the ratio of the peak heights from the calibration gas and sample gas multiplied by the concentration of the calibration gas. The sample bags were then purged with air and evacuated for the next sample.

4.1.3 Vapor Lock Test Cell

The vapor lock test was performed in a test cell rather than on the road, due to the need to maintain 100°F temperatures at various times during the year. The test cell was also the vehicle preparation cell, which included a twin-roll ECE-50-0 dynamometer, computer, and driver's aid. The cell computer was programmed to draw the driving schedule and to record the acceleration times. The test cell temperature control system was modified to provide ±2°F of set-point temperature for 70°F and 100°F. A vinyl curtain was used to isolate the closely controlled soak environment from the vapor lock test cell

Aldehyde samples were collected in graduated cylinders fitted with fritted glass-tipped bubblers. Diluted exhaust samples from the CVS representing the cold-transient, cold-stabilized, and hot-transient phases of the FTP and a composite background bag air sample were passed through triplicate scrubbers containing an aqueous solution of 0.50 percent-by-weight 3-Methyl 2-Benzothiazolone Hydrazone (MBTH) to trap the aliphatic aldehydes. The concentration (total μg/test phase) of aliphatic aldehydes as formaldehyde was determined using the MBTH Colorimetric Aldehydes procedure[4], except that the volume of MBTH solution was 50 ml in the first scrubber and 25 ml in the second and third scrubbers, and 100-ml volumetric graduates were used in place of test tubes.

Fresh scrubber solution and oxidizer were prepared biweekly. A calibration curve was established for each batch of MBTH solution. Aliphatic aldehydes as formaldehyde in concentrations from 0.013 to 3.33 ppm/ml of absorbing solution have been determined by this method. The MBTH solution has a reported[5] formaldehyde collection efficiency of 89 percent over the above-range. SCI experienced collection efficiencies ranging from 70 to 110 percent during injection tests using formaldehyde. After sample collection, the aldehyde bubblers and alcohol sample bags were carried from the test cell to the analytical laboratory.

4.1.2 Sample Analysis

The analytical laboratory was equipped as follows to determine the concentrations of methanol, ethanol, and aliphatic aldehydes in diluted vehicle exhaust and in SHED air samples:

- Two Carle Instruments, Inc. Series-R Analytical Gas Chromatographs (GC) provided automatically programmed gas sampling valves, for repeatable gas sampling and analysis and accelerated backflush-to-waste. These GC's were used for methanol and ethanol determinations.

- Two Carle Instruments, Inc. Omniscribe Model 7302 dual-pen recorders, each with solid state electronic integrators, provided both the peak height and integrated waveforms of the GC's outputs.

- One Bausch and Lomb Spectronic 20 Spectrophotometer was used for colorimetric analysis of total aliphatic aldehydes absorbed in MBTH reagent.

The GC's were equipped with two columns: (1) a stripper column to remove the majority of interfering hydrocarbons, and (2) an alcohol selective column for separating ethanol and methanol. The stripper column was packed with GE Silicone SF 96, coated on Chromosorb T

Section 4

TEST METHODOLOGY

This section describes the emission test facility, test equipment, and test procedures used during this program. Separate paragraphs are devoted to the following topics:

- Laboratory Description
- Emission Testing
- Cold-Start Driveability Testing
- Vapor Lock Testing
- Quality Control

4.1 LABORATORY DESCRIPTION

SCI operated an emission testing laboratory in Anaheim, California, where the Controlled Fleet Test program was conducted. The test facility and equipment are described in Appendix D. Special test equipment which was added to the facility for this program included the following:

- Sample collection system for aldehydes and alcohol emissions
- Analytical laboratory
- Vapor lock test cell

4.1.1 Sample Collection for Aldehydes and Alcohol Emissions

The CVS systems in each cell were modified to permit collection of alcohol and aldehyde samples. Alcohol samples were collected in 10-liter Tedlar bags mounted in separate bag racks. A separate bag was used for each phase of the FTP and for a background air sample throughout the FTP.

For evaporative emissions, the SHED Analytical System was also modified to include 10-liter Tedlar bags and a gas-sampling system for collection of alcohol samples from the SHED. Sample bags were collected at the beginning and at the end of each phase of the SHED test.

Table 5-1 displays the number of replicate tests for each fuel/group/model/car combination. An aspect of the experimental design which is of particular concern was the lack of equal replication which was necessitated by unacceptable variate values for one or more of the emissions variates on a few tests. An equally-replicated design would have two replicates per factor combination. The lack of equal replication complicated the analysis and resulted in certain hypotheses of interest being non-testable. For these reasons, whenever a particular variate had more than two replications for any fuel/group/model/car combination, only two replicates of those combinations were included in the analysis of that variate. This resulted in the discarding of at most eight of 128 observations on a variate, but it enabled all hypotheses of interest to be tested. The actual data set used for the analyses of variance is given in Appendix B.

For each of the fifteen emissions, fuel economy, and driveability variates, analysis of variance tables are presented in Appendix G. Significance probabilities (i.e., $P[F>F_{calculated}]$) were determined for each effect listed in the ANOVA tables. Any fixed effects which produced significant F statistics were analyzed further to determine which factor levels are significantly different. To do so, Fisher's least significant difference (LSD) procedure was applied to individual main effect or interaction means, as appropriate.[10]

In the following analyses, all main effects and interactions of fixed effects involving the fuel factor were tested against the FC(GM) interaction term. All other fixed effect main effects and interactions were tested against the C(GM) term. The (nested) main effect for cars and the fuel/car (nested) interaction effect were each tested against the (within) error term.

Once a main effect or interaction is judged to be significant, its means (averages) for each level or combination of factor levels were tabulated and compared using Fisher's least significant difference procedure: two means, $\bar{y}_1$ and $\bar{y}_2$, were judged significantly different at a significance level α if

$$\bar{y}_1 - \bar{y}_2 \quad > t_{\alpha/2}(\nu)(s^2[n_1^{-1} + n_2^{-1}])^{1/2}$$

where s^2 is the mean square upon which the effect is judged significant (MSC[GM] or MSFC[GM]), ν is the degrees of freedom associated with s^2, and n_1 and n_2 are the number of observations used to calculate $\bar{y}_1$ and $\bar{y}_2$, respectively. With each table of means, the cutoff value for significance,

$$LSD_\alpha = t_{\alpha/2}(\nu)(s^2[n_1^{-1} + n_2^{-1}])^{1/2},$$

is presented for α = .10 and α = .05.

TABLE 5-1. NUMBER OF REPLICATES FOR EACH FUEL, GROUP, MODEL, AND CAR COMBINATION

FUEL (i)	GROUP (j)	MODEL (k)	CAR 1	CAR 2
Base	Open	O	2	2
		C	3	
		P	3	2
	Closed	O	4	2
		C	3	
		P	2	2
02B0	Open	O	2	2
		C	3	
		P	2	2
	Closed	O	2	2
		C	2	
		P	2	2
02B1	Open	O	2	2
		C	2	
		P	2	2
	Closed	O	3	2
		C	2	
		P	2	2
05B0	Open	O	2	2
		C	2	
		P	2	2
	Closed	O	2	2
		C	2	
		P	2	2
05B3	Open	O	2	2
		C	2	
		P	2	2
	Closed	O	2	2
		C	3	
		P	2	2
08B2	Open	O	2	2
		C	2	
		P	2	2
	Closed	O	2	2
		C	2	
		P	2	2

5.3 INTERPRETATION OF ANALYSIS OF VARIANCE RESULTS

Results of the analyses of variance runs described earlier are shown in Appendix G. Of the nine effects tested for each performance variate, only the five effects involving fuel -- FUEL, FUEL x GROUP, FUEL x MODEL, FUEL x GROUP x MODEL, and FUEL x CAR (GROUP x MODEL) -- are discussed. Table 5-2 summarizes the analysis of variance results, indicating which of these effects were significant at a 0.1 significance level (90 percent confidence level) for each performance variate.

The fuel-by-car interaction results will be discussed first. This interaction was significant for four performance variates: FTP NO_x emissions, SHED organic emissions, SHED methanol emissions, and driveability. Thus, the effect of fuel on each of these variates was significantly different between the two cars of each pair of cars of the same model and car group. No investigations were made to define why these supposedly identical cars responded differently to the fuels, so no explanations are available. Since this was a random effect (not part of the experimental design), it will not be discussed further.

The analysis of variance results for the remaining effects involving fuel were used to define data groups for which means were computed. These means are presented in Table 5-3. Since the three-way (FUEL x GROUP x MODEL) interaction was significant for combined fuel and energy economy, means were computed for all thirty-six combinations of these three factors. Likewise, the FUEL x MODEL interaction was significant for FTP methanol emissions, so means were computed for all eighteen combinations of these two factors. Where there were significant differences in fuel response among the car groups, it would be misleading to report ten-car means. They are, therefore, not included in Table 5-3. For the remaining performance variates, means were computed for each of the six fuels. (Table 5-3 shows means-by-fuel for FTP aldehyde emissions and vapor lock, even though the fuel effects were not significant.)

Appendix G also shows least significant differences (LSD's), which were used to compare any given pair of means. Any two means which differ by a value greater than the appropriate LSD are significantly different. For this study, comparisons between eight fuel pairs (each of the five alcohol fuels versus base, 02B0 versus 02B1, 05B0 versus 05B3, and 02B0 versus 05B0) were of interest. Table 5-4 presents results of LSD comparisons of means at a significance level of 0.1.

The means and LSD's are also shown graphically in Figures 5-1 through 5-9 for all performance variates that were significantly affected by fuel.

TABLE 5-2. SUMMARY OF ANALYSIS OF VARIANCE RESULTS

	EFFECT				
	FUEL	FUEL×GROUP	FUEL×MODEL	FUEL×GROUP×MODEL	FUEL×CAR
FTP ORGANIC EMISSIONS	X				
FTP CO EMISSIONS	X				
FTP NOX EMISSIONS	X				X
FTP ALDEHYDE EMISSIONS					
FTP METHANOL EMISSIONS	X		X		
SHED ORGANIC EMISSIONS	X				X
SHED METHANOL EMISSIONS	X				X
CRC DRIVEABILITY	X				X
VAPOR LOCK					
COMBINED FUEL ECONOMY	X		X	X	
COMBINED ENERGY ECONOMY	X		X	X	

"X" INDICATES EFFECTS FOUND SIGNIFICANT AT 0.10 SIGNIFICANCE LEVEL

TABLE 5-3. SUMMARY OF MEANS FOR DATA GROUPS DEFINED BY ANALYSIS OF VARIANCE RESULTS

	CAR MODEL	CAR GROUP	FUEL BASE	FUEL 02BO	FUEL 02B1	FUEL 05BO	FUEL 05B3	FUEL 08B2
FTP ORGANICS, G/MI	ALL	BOTH	0.32	0.29	0.25	0.31	0.28	0.28
FTP CO, G/MI	ALL	BOTH	4.38	3.81	3.18	3 32	2.55	2.58
FTP NOX, G/MI	ALL	BOTH	0.98	1.10	1.14	1.24	1.26	1.33
*FTP ALDEHYDES, MG/MI	ALL	BOTH	19.23	15.16	18.62	19.48	15.96	17.98
FTP METHANOL, MG/MI	C	BOTH	-3.30	8.35	21.12	20.15	25.50	22.00
	O	BOTH	1.95	6.65	6.06	11.22	5.97	11.20
	P	BOTH	0.92	4.05	4.54	13.95	7.97	11.75
SHED ORGANICS, G/TEST	ALL	BOTH	2.88	4.55	4.11	6.93	5.71	7.16
SHED METHANOL, G/TEST	ALL	BOTH	0.06	0.75	0.53	1.51	1.14	1.79
DRIVEABILITY, TOTAL WEIGHTED DEMERITS	ALL	BOTH	50.50	77.85	83.35	120.35	123.20	123.05
*VAPOR LOCK, % INCREASE	ALL	BOTH	-3.62	-3.18	-2.59	-1.37	-3.09	1.37
COMBINED FUEL ECONOMY, MPG	C	CLOSED	21.73	21.31	21.16	20.68	20.67	20.49
	C	OPEN	21.89	20.66	21.09	20.14	19.76	19.48
	O	CLOSED	24.61	24.12	25.05	24.85	24.78	24.64
	O	OPEN	26.50	26.46	26.63	26.27	26.47	25.90
	P	CLOSED	21.48	21.47	21.50	21.00	21.07	20.83
	P	OPEN	21.64	21.62	21.67	21.43	21.18	21.30
COMBINED ENERGY ECONOMY, MI/MBTU	C	CLOSED	189.12	184.70	185.46	186.81	187.23	190.29
	C	OPEN	190.49	179.02	184.80	181.93	178.94	180.83
	O	CLOSED	214.15	209.03	219.58	224.45	224.48	228.80
	O	OPEN	230.65	229.28	233.39	237.34	239.76	240.51
	P	CLOSED	186.95	186.04	188.41	189.71	190.82	193.45
	P	OPEN	188.32	187.36	189.94	193.56	191.84	197.74

* Overall fuel effects not significant at 0.1 significance level.

NOTE: This table is computer-generated and, on occasion, the number of significant digits exceeds what is justified by the experimental program.

TABLE 5-4. SIGNIFICANT CHANGES FOR SELECTED FUEL PAIRS

	CAR MODEL	CAR GROUP	FUEL PAIRS 02BO VS. BASE	02B1 VS. BASE	05BO VS. BASE	05B3 VS. BASE	08B2 VS. BASE	02B1 VS. 02BO	05B3 VS. 05BO	05BO VS. 02BO
FTP ORGANICS, G/MI	ALL	BOTH	-0.04	-0.07	NS	-0.05	-0.04	-0.03	-0.04	NS
FTP CO, G/MI	ALL	BOTH	-0.58	-1.21	-1.06	-1.83	-1.80	-0.63	-0.77	NS
FTP NOX, G/MI	ALL	BOTH	NS	0.16	0.26	0.29	0.35	NS	NS	NS
FTP METHANOL, MG/MI	C	BOTH	11.65	24.42	23.45	28.80	25.30	12.77	NS	11.80
	O	BOTH	NS	NS	9.27	NS	9.25	NS	NS	NS
	P	BOTH	NS	NS	13.02	7.05	10.82	NS	NS	9.90
SHED ORGANICS, G/TEST	ALL	BOTH	NS	NS	4.05	2.83	4.28	NS	NS	2.38
SHED METHANOL, G/TEST	ALL	BOTH	0.70	NS	1.46	1.08	1.73	NS	NS	0.76
DRIVEABILITY, TOTAL WEIGHTED DEMERITS	ALL	BOTH	27.35	32.85	69.85	72.70	72.55	NS	NS	42.50
COMBINED FUEL ECONOMY, MPG	C	CLOSED	NS	-0.57	-1.05	-1.06	-1.24	NS	NS	-0.63
	C	OPEN	-1.23	-0.80	-1.75	-2.13	-2.41	NS	NS	-0.52
	O	CLOSED	-0.48	0.45	NS	NS	NS	0.93	NS	0.72
	O	OPEN	NS	NS	NS	NS	-0.60	NS	NS	NS
	P	CLOSED	NS	NS	-0.48	-0.41	-0.65	NS	NS	-0.47
	P	OPEN	NS	NS	NS	-0.46	-0.34	NS	NS	NS
COMBINED ENERGY ECONOMY, MI/MBTU	C	CLOSED	-4.42	NS	NS	NS	NS	NS	NS	NS
	C	OPEN	-11.47	-5.68	-8.55	-11.54	-9.66	5.79	NS	NS
	O	CLOSED	-5.12	5.43	10.29	10.33	14.65	10.56	NS	15.42
	O	OPEN	NS	NS	6.69	9.11	9.86	4.12	NS	8.06
	P	CLOSED	NS	NS	NS	3.88	6.51	NS	NS	3.67
	P	OPEN	NS	NS	5.24	3.52	9.42	NS	NS	6.19

"NS" INDICATES DIFFERENCES NOT SIGNIFICANT AT 0.1 SIGNIFICANCE LEVEL.

NOTE: This table is computer-generated and, on occasion, the number of significant digits exceeds what is justified by the experimental program.

5.4 DISCUSSION OF RESULTS

The results shown in Tables 5-3 and 5-4 and Figures 5-1 through 5-9 will be discussed individually for each performance variate. In the tables and figures, the fuels are shown in order of increasing oxygen content. For each, any apparent trends with increasing oxygen content or effects due to the presence or absence of isobutanol in the fuel will be discussed. Because of the design of the fuel set, the effect of isobutanol could not be isolated. Oxygenated fuels showing results not significantly different from the base fuel will be identified. Apparent anomalies in the data will be mentioned. The results will be compared with the literature only with performance variates for which the effect of adding alcohol is well established.

5.4.1 FTP Organic Emissions

Figure 5-1 shows that all of the oxygenated fuels, with the exception of Fuel 05B0, gave significantly lower FTP organic emissions than the base fuel. The high similarity of the results between Fuel 05B0 and the base fuel was not explicable from the data available. Co-solvent may have had an effect on FTP organic emissions, but this effect was uncertain due to fuel composition or volatility differences. Although not shown on the figure, the closed-loop cars gave higher organic emissions than open-loop cars, but the fuel effects were similar for both groups.

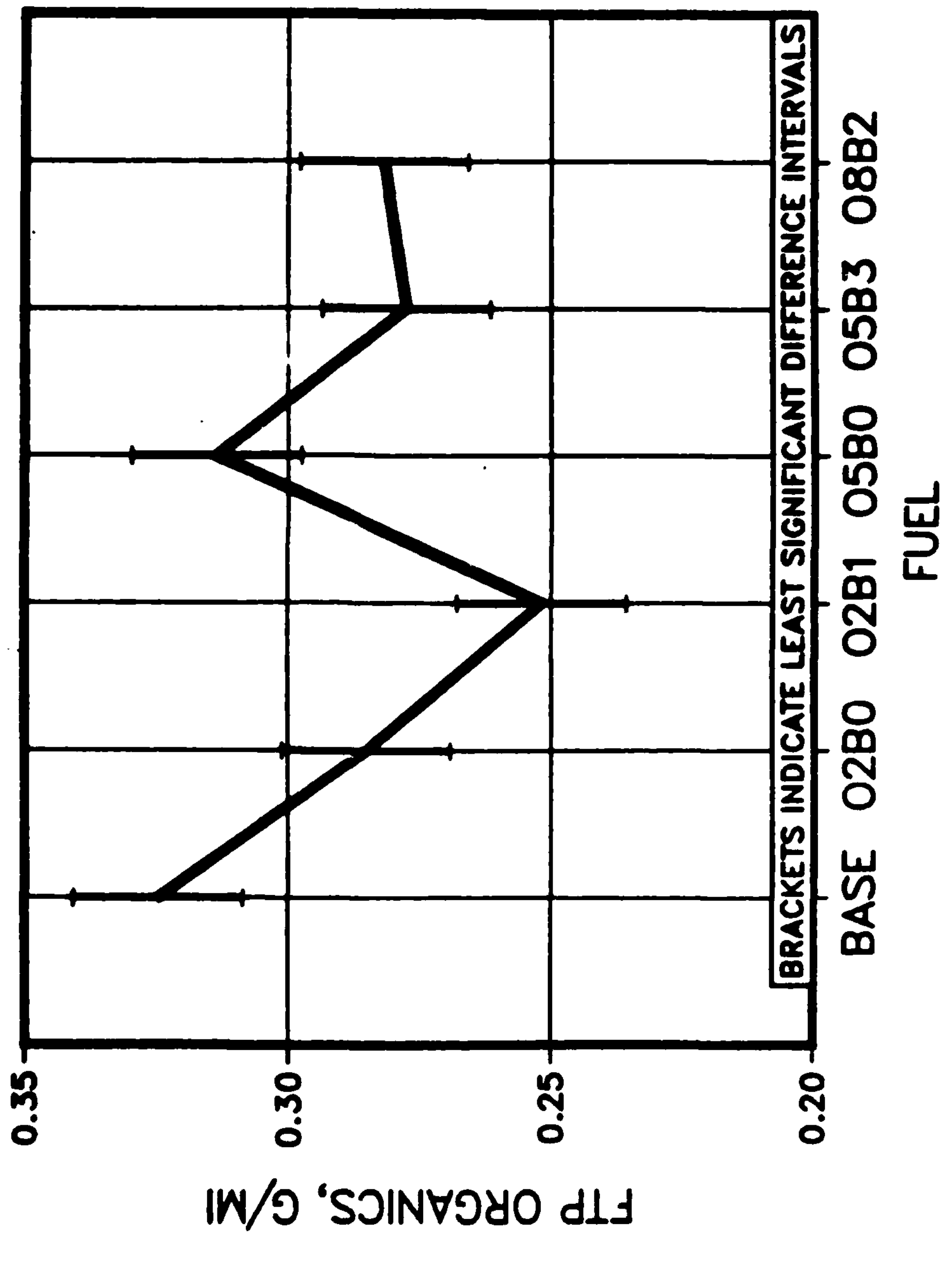
5.4.2 FTP CO Emissions

In Figure 5-2, all of the oxygenated blends gave lower CO emissions than the base fuels. There also appeared to be a co-solvent effect; CO emissions tended to be lower with added co-solvent than without for blends having similar oxygen content. Again, this was confounded by the volatility effect. The reduction in CO emissions can be explained by the well-known leaning effect of oxygen in alcohols. The results are consistent with the literature. Fuel 08B2 was an anomaly, because it would have been expected to give a lower CO than observed with Fuel 05B3. The possibility exists that there was a limit reached on the reduction of CO emissions as the oxygen level increased.

5.4.3 FTP NO_x Emissions

Figure 5-3 shows that increasing oxygen content increased NO_x emissions. There appeared to be no significant effect of co-solvents on NO_x emissions. There was no significant difference between the base fuel and Fuel 02B0. Although not shown on the figure, the closed-loop cars gave lower NO_x emissions than open-loop cars, but the fuel effects were similar for both groups.

FIGURE 5-1


BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
FTP ORGANICS, G/MI
0.35
0.30
0.25
0.20
FUEL
BASE
O2B0
O2B1
O5B0
O5B3
O8B2

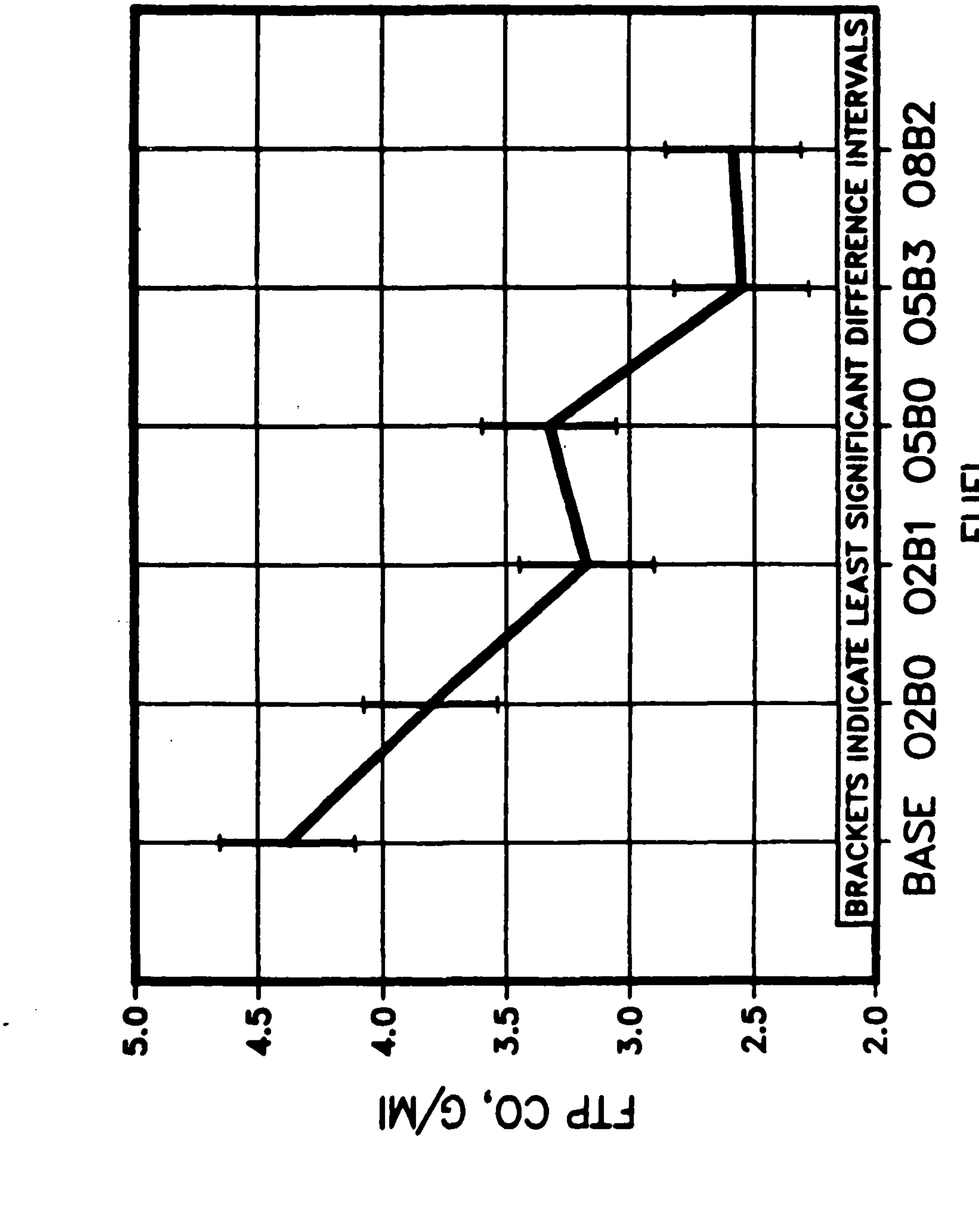
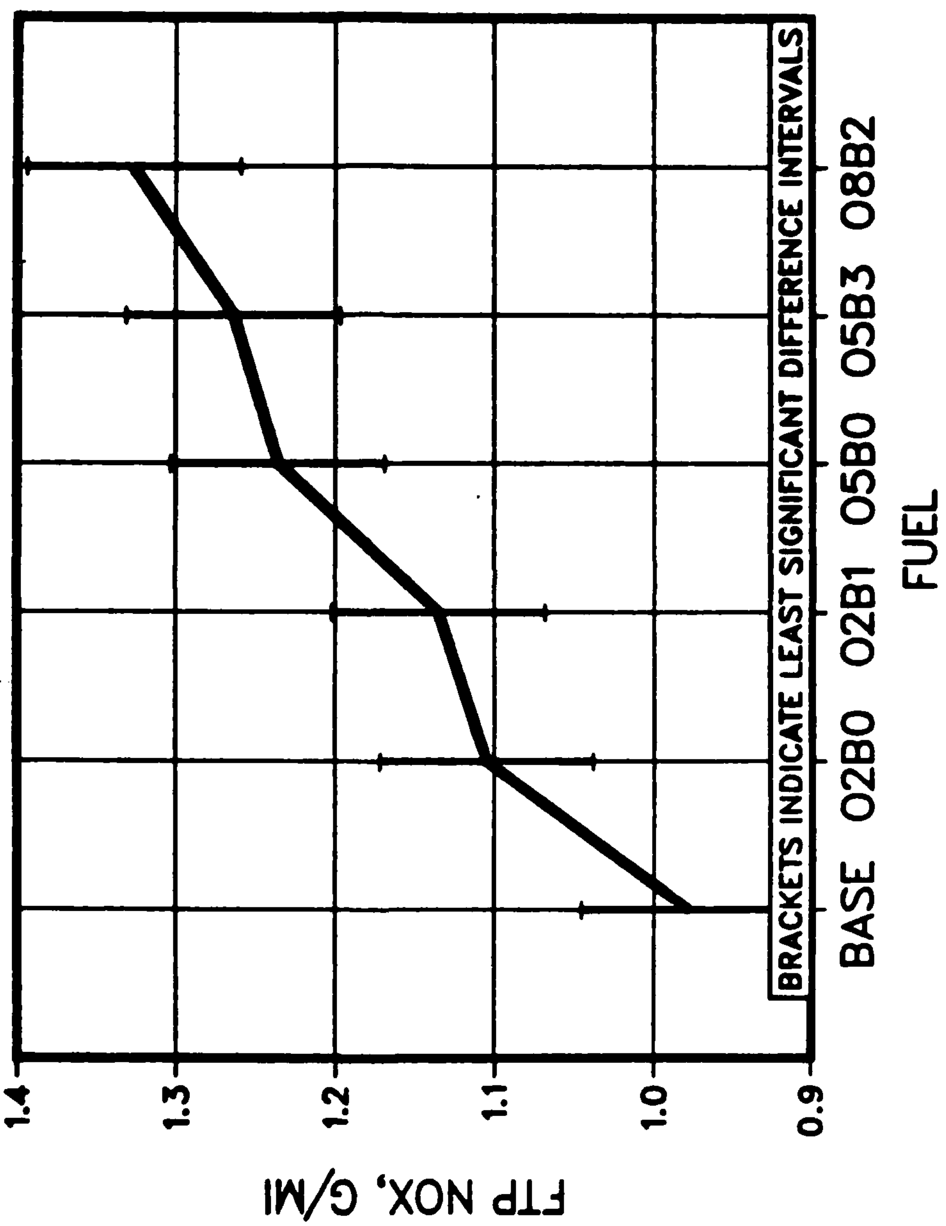

BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
FTP CO, G/MI
5.0
4.5
4.0
3.5
3.0
2.5
2.0
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

FIGURE 5-2

FIGURE 5-3



BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
FTP NOX, G/MI
1.4
1.3
1.2
1.1
1.0
0.9
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

5.4.4 Methanol Emissions

In general, as shown in Figure 5-4, the fuels with alcohol gave higher methanol emissions than the base fuel. The effect was larger for Model C than for Models O and P. The effects were sufficiently small for Models O and P that the 2 percent oxygen fuels gave methanol emissions not significantly different than the base fuel. In addition, the methanol emissions for Fuel 05B3 were not significantly different than those with the base fuel in Model O.

5.4.5 Aldehyde Emissions

Because the variation in the aldehyde measurements was so high, fuel effects on aldehyde emissions could not be identified.

5.4.6 SHED Organic Emissions

Figure 5-5 demonstrates that, compared with the base fuel, the high oxygen-content fuels showed an increase in SHED organics, but the low oxygen-content fuels were not significantly different. The effect of co-solvent was not statistically significant, nor was the difference in SHED organics between the 5 percent and the 8 percent fuels. Hydrocarbon emissions can be derived from organic emissions as shown by the equation on page B-1 of Appendix B; the trends in hydrocarbon emissions were similar to those shown for organic emissions.

5.4.7 SHED Methanol Emissions

Figure 5-6 shows that generally, as methanol content increased, the SHED methanol emissions also increased. Fuel 02B0 was statistically different from the base fuel, but Fuel 02B1 was not. Co-solvent effects were not statistically significant.

5.4.8 Driveability

As demonstrated in Figure 5-7, driveability demerits were significantly higher with all the alcohol fuels than with the base fuel. While there was no statistically significant difference between the 5 percent and 8 percent oxygen-content fuels, there was such a difference between this group of fuels and the 2 percent oxygen fuels. Based upon what is known about the leaning effect, the expectation was that the 8 percent oxygen fuel would have given higher driveability demerits than the 5 percent oxygen fuels. Co-solvent had no effect.

FIGURE 5-4

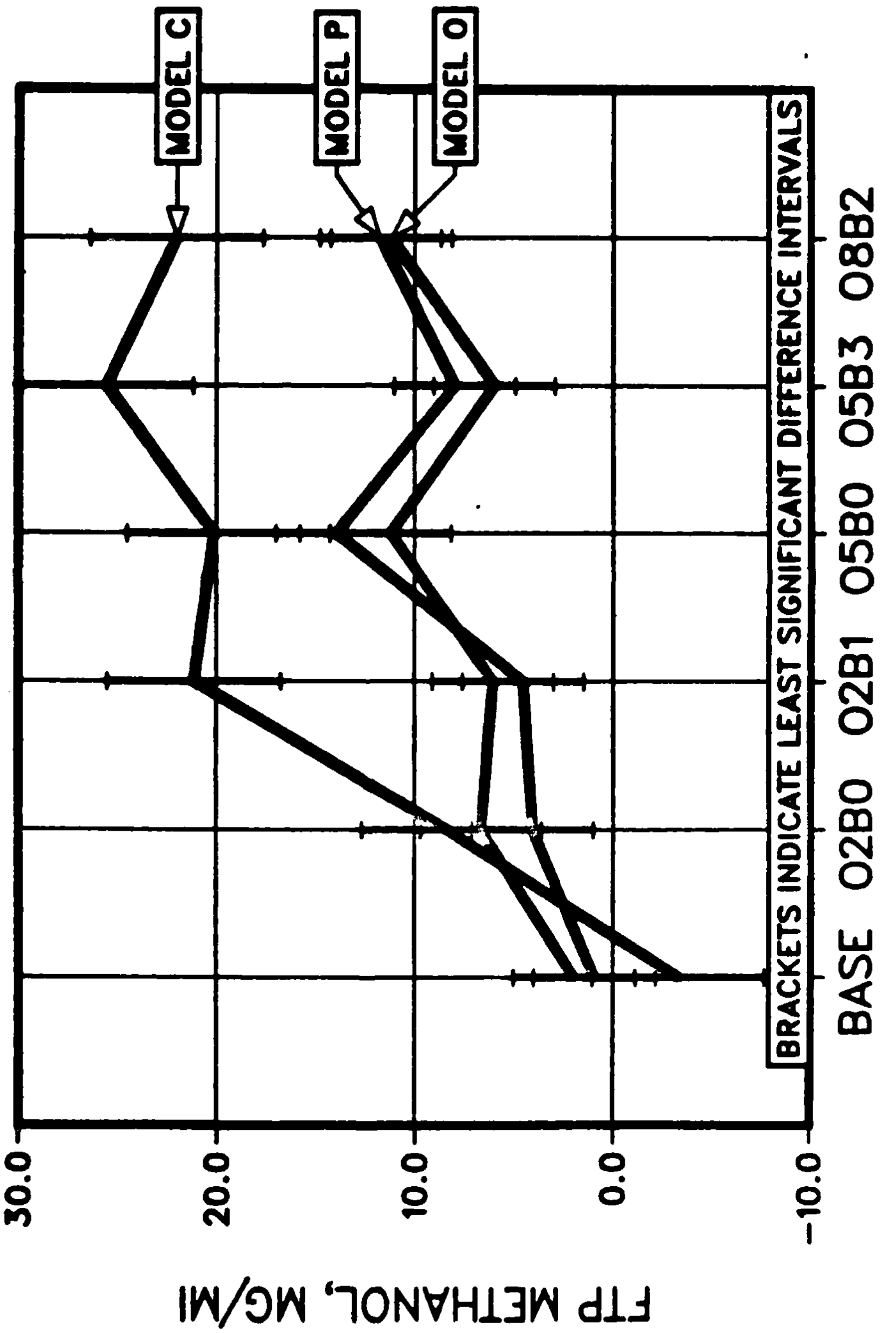
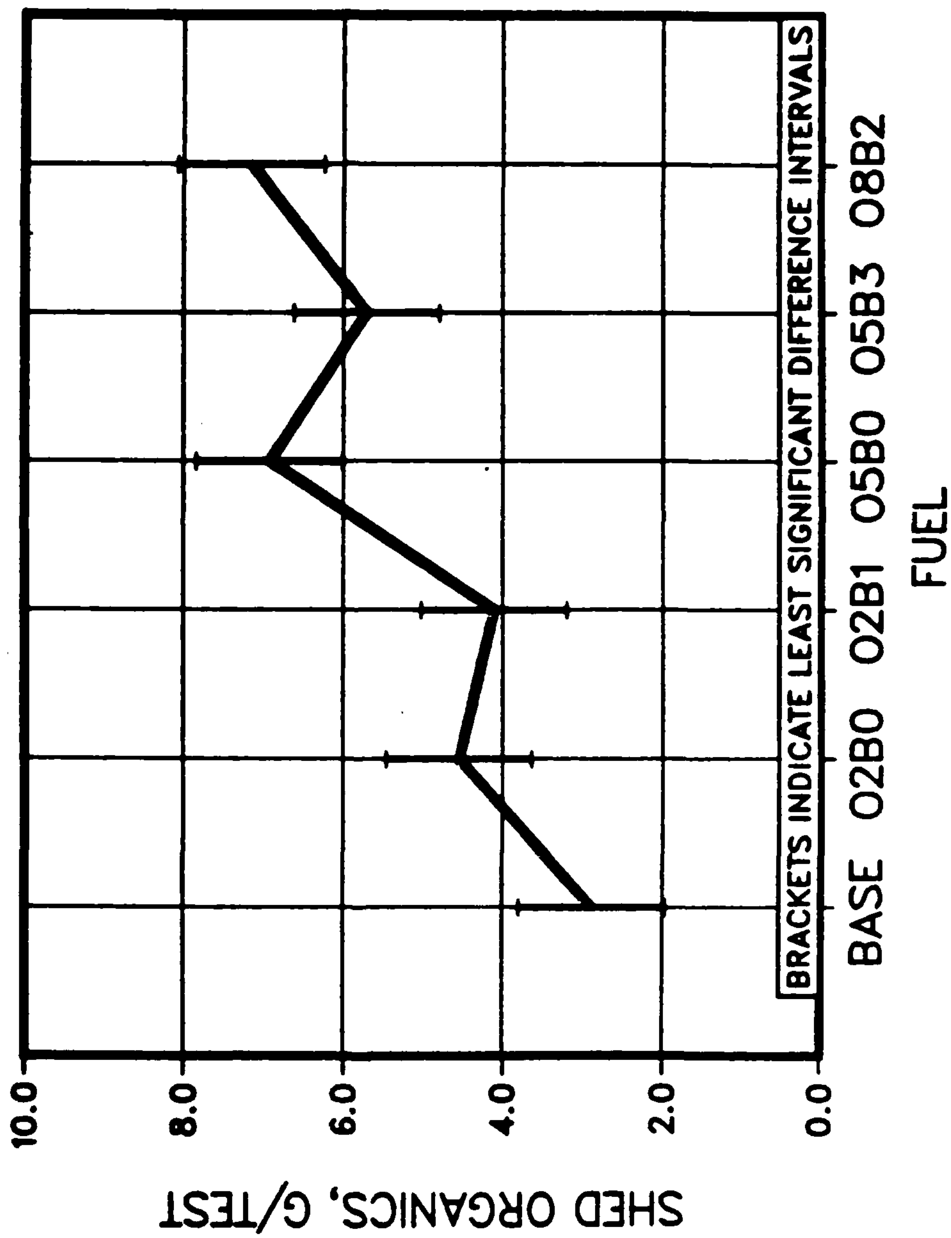

MODEL C
MODEL P
MODEL O
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL
30.0
20.0
10.0
0.0
-10.0
FTP METHANOL, MG/MI

FIGURE 5-5



SHED ORGANICS, G/TEST
10.0
8.0
6.0
4.0
2.0
0.0
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

FIGURE 5-6

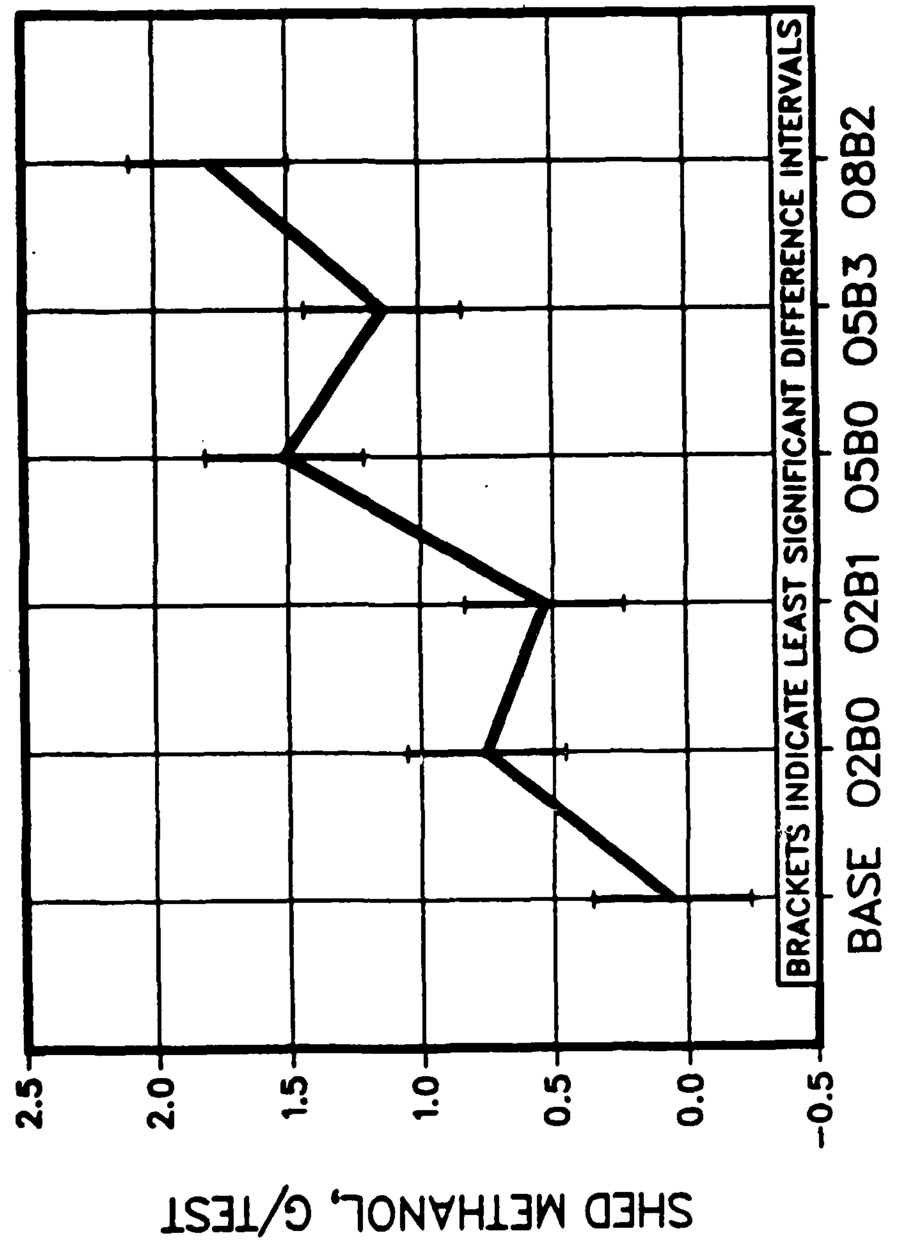

BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
SHED METHANOL, G/TEST
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

TABLE B-2. INDIVIDUAL TEST DATA

					FTP									HFET									DIURNAL				HOT SOAK					FTP	
CAR	TF	ODO	RUN	DATE	ORG	HC	CO	CO_2	NO_x	MPGC	MPGV	MPBC	MPBV	ORG	HC	CO	CO_2	NO_x	MPGC	MPGV	MPBC	MPBV	ORG	HC	ET	MC	ORG	HC	ET	ME	ALD	ET	MC
O4-1	1 5	13057	6733.0	111081	0.237	0.225	2.136	359.3	1.704	24.404	22.155	220.29	199.78	0.052	0.052	0.029	267.8	2.146	33.095	32.641	298.74	294.64	0.586	0.534	11.1	61.8	1.037	0.975	10.8	75.6	15.0	0.0	0.70
	2 5	13174	7670.0	10782	0.133	0.123	1.933	357.0	1.573	24.714	24.029	223.08	216.90	0.055	0.055	0.176	270.9	1.807	32.682	33.175	295.00	299.46	0.523	0.457	0.0	91.8	0.787	0.663	-0.2	172.2	13.4	0.0	0.40
	1 6	13060	6751.0	111181	0.161	0.151	1.816	370.4	1.881	23.484	22.441	204.61	195.52	0.059	0.059	0.022	264.6	2.499	33.142	32.918	288.76	286.81	0.347	0.312	11.0	38.3	0.991	0.863	10.8	166.7	13.5	0.3	0.40
	2 6	13172	7608.0	10682	0.142	0.135	1.050	362.8	1.808	24.055	24.408	209.58	212.66	0.055	0.055	0.013	263.6	2.339	33.274	33.463	289.90	291.55	0.708	0.625	0.0	115.1	1.622	1.424	10.7	264.0	8.9	0.3	0.40
	1 7	13077	6786.0	111781	0.241	0.229	2.081	365.1	1.651	24.040	22.950	210.96	201.40	0.067	0.067	0.009	268.3	2.149	32.710	32.490	287.04	285.12	0.877	0.788	0.0	123.1	1.623	1.403	10.8	295.4	14.4	0.0	1.70
	2 7	13088	6835.0	112081	0.151	0.142	1.101	360.1	1.891	24.376	23.870	213.72	209.47	0.060	0.060	0.011	269.8	2.016	32.531	33.150	285.48	290.91	0.861	0.785	-11.1	116.0	1.800	1.597	10.7	271.4	11.1	0.0	1.10
	1 8	13070	6766.0	111381	0.206	0.187	1.717	349.4	2.200	23.928	22.416	206.13	193.10	0.052	0.052	0.009	257.9	3.121	32.706	32.619	281.75	280.99	1.184	1.019	-0.1	229.8	1.776	1.467	-0.1	429.7	24.1	0.0	1.60
	2 8	13176	7713.0	10882	0.105	0.100	0.308	345.3	2.176	24.383	24.656	210.05	212.40	0.072	0.072	0.006	256.3	2.927	32.894	33.445	283.36	288.11	1.212	1.086	-0.1	175.4	2.182	1.893	10.7	390.7	1.5	0.0	4.60
	1 9	13094	6849.0	112381	0.202	0.185	2.644	363.5	2.061	22.946	22.086	209.39	200.57	0.059	0.059	0.020	263.6	2.891	32.033	32.376	290.91	294.02	0.646	0.564	-0.1	114.6	2.098	1.806	-0.1	406.1	13.1	0.0	8.50
	2 9	13169	7549.0	10582	0.153	0.142	1.092	353.2	2.090	23.775	24.181	215.91	219.60	0.060	0.060	0.094	259.7	2.734	32.491	32.994	295.07	299.64	0.779	0.693	-11.1	130.3	1.982	1.627	10.6	482.8	11.1	0.0	3.20
	110	13147	7294.0	121881	0.225	0.202	2.555	360.6	2.035	22.793	21.950	205.72	198.11	0.031	0.031	0.004	258.3	2.802	32.223	31.960	290.83	288.46	0.750	0.664	0.0	129.0	2.081	1.728	0.0	490.0	24.2	0.0	6.00
	210	13148	7332.0	121981	0.142	0.129	1.050	347.0	1.920	23.715	24.150	214.05	217.97	0.040	0.040	-0.002	256.0	2.718	32.512	33.100	293.44	298.75	0.875	0.748	0.0	176.5	1.934	1.573	10.8	491.0	12.5	0.0	4.00
O4-2	1 5	13058	7225.0	111081	0.326	0.321	2.570	387.4	1.163	22.598	22.701	203.78	204.71	0.023	0.023	0.010	295.6	1.451	29.995	30.540	270.75	275.67	0.770	0.757	11.1	7.5	0.844	0.811	-0.1	45.3	7.1	0.0	0.00
	2 5	13128	7675.0	120781	0.215	0.206	4.239	376.6	1.256	22.994	22.705	207.56	204.95	0.018	0.018	0.058	282.9	1.796	31.159	31.751	281.26	286.60	0.818	0.807	0.0	15.2	0.958	0.950	-11.0	22.5	11.0	0.0	1.00
	1 6	13061	7241.0	111161	0.210	0.186	2.421	381.8	1.475	22.721	22.197	197.96	193.40	0.053	0.053	0.007	278.0	2.146	31.557	31.682	274.95	276.04	0.525	0.490	11.0	38.1	1.057	0.976	-0.1	112.8	25.2	0.0	6.20
	2 6	13079	7305.0	111981	0.155	0.131	2.894	378.2	1.241	22.900	22.491	199.52	195.96	0.040	0.040	0.010	285.8	1.813	30.706	31.797	267.54	277.04	0.681	0.615	0.0	91.7	1.487	1.308	-0.1	248.2	19.1	0.0	10.80
	1 7	13076	7287.0	111781	0.271	0.250	3.126	378.3	0.731	22.988	22.429	200.85	196.83	0.051	0.051	0.001	283.2	2.411	31.017	31.815	272.19	279.19	0.689	0.573	0.0	161.8	1.313	1.311	-66.1	67.0	19.2	0.0	8.00
	2 7	13089	7339.0	112081	0.197	0.186	2.842	381.4	1.211	22.733	22.711	199.50	199.30	0.021	0.021	0.005	281.1	2.183	31.249	32.009	274.23	280.90	0.847	0.704	-0.1	199.3	1.583	1.360	10.6	299.5	14.0	0.0	2.90
	1 8	13069	7256.0	111381	0.344	0.311	2.251	361.7	1.818	23.037	22.347	193.46	192.51	0.052	0.052	-0.003	263.1	2.517	32.055	31.764	276.13	273.63	0.769	0.670	-0.1	137.9	1.165	1.008	-0.1	218.7	29.1	0.0	12.90
	2 8	13095	7324.0	111981	0.288	0.271	3.119	377.1	1.971	22.008	22.171	187.58	190.99	0.009	0.009	0.001	271.3	2.121	31.109	31.244	267.98	269.15	0.899	0.825	-11.2	114.3	1.410	1.172	-0.1	330.6	15.3	0.0	7.10
	1 9	13131	7670.0	121081	0.285	0.258	2.476	360.3	1.799	23.147	22.639	210.21	205.60	0.051	0.051	0.020	274.5	2.531	30.784	31.167	279.57	283.04	0.740	0.685	-0.1	76.8	1.431	1.250	10.6	241.3	29.3	0.0	6.40
	2 9	13136	7706.0	121181	0.296	0.273	3.523	370.6	2.021	22.428	21.942	203.68	199.27	0.031	0.031	0.005	273.4	3.097	30.908	31.009	280.69	281.61	0.674	0.584	10.9	114.5	1.446	1.338	10.7	140.0	20.3	0.0	9.70
	110	13139	7719.0	121581	0.297	0.274	2.828	376.2	2.096	21.819	22.294	176.93	201.22	0.055	0.055	0.011	276.1	3.153	30.136	30.959	272.00	279.43	0.751	0.620	22.0	161.2	1.612	[illegible]	21.4	610.9	23.9	0.3	5.70
	210	13175	7855.0	10982	0.209	0.201	2.286	375.5	2.109	21.716	22.176	176.00	200.15	0.071	0.071	0.006	280.6	2.220	29.650	30.792	267.61	277.92	0.649	0.539	-0.1	153.2	1.667	1.519	10.6	195.8	6.0	0.0	4.00
C4-1	2 5	12862	6148.0	80481	0.501	0.490	6.902	421.3	0.391	20.447	20.913	184.57	188.77	0.022	0.022	0.025	285.8	0.535	31.020	33.290	280.01	300.49	0.592	0.589	-11.0	15.2	1.873	1.838	10.8	37.6	15.1	0.0	-0.50
	3 5	12873	6294.0	80781	0.475	0.438	6.213	417.5	0.770	20.682	21.520	186.68	194.25	0.013	0.013	0.037	269.0	0.825	32.877	33.559	296.77	302.92	1.840	1.813	-0.1	38.0	2.031	1.983	0.0	67.0	38.0	0.0	10.80
	4 5	13165	7450.0	123081	0.256	0.227	11.156	389.6	0.706	21.577	21.899	194.76	197.67	-0.001	-0.001	0.087	267.8	0.955	33.101	36.836	298.79	332.50	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	29.9	0.4	7.70
	5 5	13167	7490.0	123181	0.248	0.238	3.555	359.6	0.793	23.591	24.014	212.94	216.76	0.028	0.028	0.007	264.1	0.993	33.572	34.394	303.04	310.46	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	11.2	1.4	1.00
	1 6	12697	6271.1	61481	0.274	0.258	3.078	388.8	0.611	22.250	21.443	193.86	186.83	0.037	0.037	0.002	264.2	0.805	33.212	34.318	289.37	299.00	1.106	1.016	10.9	113.8	2.045	1.834	0.0	293.1	14.3	0.0	6.80
	2 6	12695	6322.0	81681	0.329	0.315	3.478	404.2	0.874	21.372	21.508	186.21	187.39	0.058	0.058	0.092	261.2	0.917	33.555	34.179	292.36	297.79	4.467	4.198	0.0	373.4	5.407	4.804	-0.1	837.5	12.4	0.0	5.20
	4 6	12939	5538.0	91181	0.223	0.206	2.704	397.1	0.924	21.831	21.963	190.21	191.36	0.029	0.029	0.005	262.2	0.999	33.456	34.383	291.50	297.57	1.512	1.385	0.0	175.9	5.935	5.764	21.4	216.9	13.2	0.9	8.40
	1 7	12999	6793.0	101581	0.302	0.287	3.901	406.7	0.624	21.227	19.977	186.28	175.31	-0.004	-0.004	0.015	273.2	0.432	32.152	33.117	282.15	290.62	1.360	1.150	0.0	291.5	3.113	2.056	-0.3	1468.2	15.3	0.0	4.00
	3 7	13066	6884.0	111281	0.279	0.287	4.451	410.2	0.924	21.006	20.184	184.34	177.13	-0.021	-0.021	0.105	288.8	0.972	30.406	32.932	266.83	289.00	1.465	1.327	0.0	192.0	6.816	5.879	-0.1	1301.3	1.5	0.0	12.80
	2 8	12912	6445.0	82881	0.247	0.239	2.849	369.0	1.129	21.405	21.752	184.39	187.38	0.024	0.024	0.002	258.8	1.954	32.599	33.316	280.82	287.00	2.647	2.313	10.8	453.1	8.557	7.202	21.1	1861.3	7.9	0.0	2.00
	3 8	12924	6494.0	90381	0.261	0.256	2.880	392.7	1.224	21.201	20.543	182.64	176.97	0.030	0.030	0.040	259.1	2.201	32.550	33.449	280.40	288.14	2.517	2.260	-11.2	367.4	5.314	4.443	10.6	1200.1	1.9	0.0	3.70
	1 9	12946	6588.0	91581	0.307	0.281	3.206	370.3	1.328	21.321	21.075	193.63	191.39	0.026	0.026	-0.001	256.3	2.107	32.963	33.632	299.35	305.43	1.217	1.024	0.0	267.5	10.752	8.733	43.1	2762.9	29.0	0.0	5.60
	2 9	12964	6642.0	92561	0.351	0.331	3.942	372.8	0.702	21.121	21.097	191.81	191.61	0.029	0.029	0.009	258.5	1.259	32.672	33.534	296.71	304.54	0.964	0.810	-0.1	214.3	10.660	8.858	21.5	2481.9	19.5	0.0	6.90
	110	12962	6658.0	100781	0.385	0.362	3.117	391.7	1.265	20.932	20.937	188.73	189.42	0.023	0.023	0.019	256.5	1.834	32.449	33.116	292.87	298.90	1.047	0.839	0.0	289.3	7.455	6.301	43.0	1560.5	10.0	0.0	18.20
	210	12993	6731.0	101391	0.359	0.336	3.595	388.8	0.534	21.050	21.274	189.99	192.01	0.007	0.007	0.002	253.8	0.755	32.797	33.143	296.02	299.14	1.087	0.905	0.0	252.3	9.519	7.980	32.4	2105.4	6.6	0.0	20.30
C4-2	2 5	12747	[illegible]	61881	0.456	0.440	4.823	407.1	0.566	21.287	21.282	192.14	172.10	0.017	0.017	0.123	306.6	0.591	28.898	30.614	260.85	276.34	1.026	1.037	-0.1	-15.2	1.961	1.950	-0.1	14.8	20.6	0.4	1.10
	3 5	12796	5938.0	71481	0.342	0.313	3.737	412.8	0.568	21.024	21.072	189.78	190.21	0.019	0.019	0.263	308.3	0.564	28.693	29.937	259.00	270.23	0.392	0.363	10.8	30.3	1.303	1.305	-10.8	7.2	36.6	0.0	2.10
	1 6	12810	5986.0	71781	0.336	0.310	5.024	415.8	0.593	20.663	21.230	160.03	184.97	0.036	0.036	2.957	323.0	0.522	27.173	29.493	236.75	256.96	0.709	0.627	-0.1	113.9	3.142	2.931	10.7	282.7	30.7	0.0	4.40
	2 6	12819	6042.0	72181	0.282	0.255	3.785	408.6	0.557	21.126	22.047	184.06	192.09	0.026	0.026	0.913	319.3	0.431	27.488	30.165	239.50	262.82	0.751	0.672	11.0	98.7	3.915	3.464	21.5	605.9	23.2	0.0	11.10
	1 7	12797	6470.0	101491	0.253	0.241	3.552	409.3	0.678	21.131	20.862	185.44	183.08	-0.001	-0.001	0.227	323.1	0.585	27.155	30.128	238.30	264.39	1.182	1.058	11.1	161.3	3.640	3.009	21.6	855.1	5.6	0.0	9.40
	2 7	13007	6537.0	102081	0.381	0.356	3.792	412.0	0.672	20.958	20.953	183.92	183.87	-0.001	-0.001	0.291	320.9	0.606	27.338	30.283	237.91	265.75	0.875	0.709	0.0	230.5	3.837	3.351	10.8	664.1	18.6	0.0	13.30
	1 8	12851	6124.0	72981	0.261	0.744	2.827	398.6	0.579	20.913	21.000	160.16	180.90	0.027	0.029	0.022	289.4	0.552	29.148	30.400	251.09	261.88	1.000	0.868	-0.1	183.1	4.288	3.381	10.6	1250.0	15.5	0.0	6.70
	2 8	12958	6174.0	73181	0.340	0.311	2.470	376.9	0.608	21.034	21.740	181.20	187.28	0.034	0.034	0.063	290.7	0.597	29.032	30.281	250.09	260.85	1.098	0.917	-0.1	251.6	3.946	3.265	10.6	935.7	28.4	0.0	9.20
	1 9	12954	6294.0	92291	0.452	0.423	3.401	296.1	0.737	20.942	21.378	190.19	194.14	0.019	0.019	0.021	292.5	0.668	28.884	30.791	262.31	277.63	0.807	0.665	0.0	197.9	3.939	3.163	21.6	1057.1	14.0	-0.9	22.20
	2 9	12762	6364.0	92481	0.431	0.401	3.715	376.0	0.517	20.957	21.299	190.32	192.53	0.015	0.015	0.050	297.6	0.473	28.368	29.992	257.80	271.56	1.433	1.173	10.9	351.0	3.058	2.351	10.8	971.7	7.4	1.1	27.30
	110	12973	6450.0	100181	0.396	0.367	2.591	395.5	0.774	20.813	20.851	187.85	188.20	0.036	0.036	0.007	284.0	0.785	29.318	30.300	264.51	273.48	1.376	1.159	11.0	290.3	6.694	5.441	42.9	1698.3	17.0	0.0	7.60
	210	12778	6441.0	100481	0.365	0.340	3.559	399.9	0.822	20.529	20.572	195.29	185.68	0.016	0.016	-0.003	281.6	0.977	29.567	30.852	266.86	278.46	1.250	1.025	0.0	312.9	6.970	5.863	10.7	1527.6	5.3	0.9	23.80
C6-1	3 5	12658	5801.6	52181	0.305	0.296	5.412	442.7	0.436	19.603	19.137	176.95	172.74	0.025	0.025	0.113	325.4	0.282	27.231	25.559	245.80	230.71	0.488	0.475	10.7	7.6	1.850	1.877	10.7	22.2	12.8	1.1	-1.60
	4 5	12723	5846.7	61081	0.296	0.260	5.681	452.8	0.579	19.168	19.068	173.02	172.12	0.030	0.030	0.198	350.7	0.313	25.257	25.101	227.99	226.58	0.731	0.728	-11.0	15.0	1.565	1.515	13.6	59.0	43.8	-2.2	-4.90
	6 5	13162	8235.0	122381	0.459	0.421	9.774	446.2	0.860	19.153	19.403	172.88	175.14	0.039	0.039	0.203	338.2	0.566	26.189	24.028	236.40	216.89	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	49.3	0.4	1.30
	1 6	12760	5926.2	62981	0.257	0.241	4.621	472.9	0.735	18.253	18.831	159.03	164.07	0.024	0.024	0.101	345.2	0.607	25.408	25.469	221.37	221.90	0.417	0.343	11.0	91.4	1.975	1.799	-0.2	245.2	17.2	0.0	4.20
	2 6	12775	5972.0	70781	0.325	0.268	4.437	474.2	0.822	18.201	18.813	158.58	163.91	0.026	0.026	0.105	344.2	0.530	25.484	24.675	222.03	214.99	0.615	0.539	-0.1	105.9	2.347	2.105	10.5	326.0	18.0	0.0	49.80
	1 7	13107	8315.5	123181	0.239	0.220	5.832	448.5	0.763	19.131	19.204	167.88	168.53	0.025	0.025	0.135	339.3	0.566	25.868	25.787	227.00	226.29	0.776	0.660	0.0	161.8	2.538	2.144	21.5	526.6	13.6	0.0	0.50
	2 7	24947	8054.8	120381	0.575	0.551	10.597	449.5	0.914	18.772	17.360	164.73	169.89	0.034	0.034	0.215	336.8	0.467	26.047	22.639	228.59	198.67	1.046	0.895	11.0	199.0	2.816	2.615	10.6	268.3	15.4	4.8	10.20
	1 8	12781	6021.3	70681	0.250	0.239	4.240	467.6	0.793	17.766	18.345	153.04	158.03	0.028	0.028	0.080	338.3	0.625	24.933	24.857	214.78	214.13	0.926	0.787	10.9	182.0	3.698	3.234	21.4	624.2	10.5	0.0	13.50
	2 8	12787	6068.4	71581	0.328	0.289	3.891	462.3	0.916	17.977	18.416	154.86	158.64	0.030	0.010	0.123	338.3	0.627	24.930	25.233	214.76	217.37	0.849	0.658	-0.1	266.0	2.745	2.269	21.4	639.9	27.3	0.0	21.70
	3 8	12901	6102.5	71581	0.376	0.362	4.441	466.0	1.058	17.795	18.349	153.30	158.07	0.047	0.049	0.414	348.3	0.589	24.177	24.356	208.27	209.81	0.719	0.517	-0.1	280.3	2.257	1.776	10.6	657.6	28.7	0.0	14.80
	1 9	13121	8105.8	120981	0.440	0.372	7.085	452.2	0.730	18.059	18.779	154.31	170.54	0.012	0.012	0.119	338.7	0.551	24.935	22.795	226.45	207.01	0.905	0.756	0.0	207.3	3.037	2.479	10.6	765.1	25.9	0.4	32.60
	2 9	13130	8150.8	121081	0.284	0.237	4.374	454.7	0.884	18.260	18.795	[illegible]	171.69	0.022	0.022	0.189	336.1	0.523	25.119	22.991	228.12	208.79	1.136	0.936	-22.3	300.1	3.195	2.548	10.7	888.2	40.4	3.5	16.80
	110	13134	8195.7	121481	0.332	0.274	4.575	459.8	0.732	17.798	18.232	[illegible]	164.83	0.029	0.029	0.128	338.0	0.576	24.612	24.668	222.14	222.65	1.023	0.816	11.0	276.2	3.187	2.600	21.4	795.1	55.0	0.4	20.10
	210	13133	8230.9	121581	0.284	0.258	4.334	451.5	0.925	17.992	18.383	163.37	165.92	0.036	0.036	0.212	335.4	0.528	24.792	23.170	223.77	209.13	1.025	0.724	10.9	407.6	3.276	2.404	21.2	1190.1	14.9	1.1	16.30

TABLE B-1. DEFINITION OF SYMBOLS USED IN TABLE B-2

CAR Alphanumeric code (A1-2)

A : 0 = open loop; C = closed loop
1 : 4 = 4 cylinders; 6 = 6 cylinders
2 : 2 = car number (1, 2, 3, or 4)

T Test number (1, 2, 3, etc.)

F Test fuel code (5 = Base Fuel; 6 = 02B1; 7 = 02B0; 8 = 05B3; 9 = 05B0; 10 = 08B2)

ODO Odometer reading at beginning of test

RUN Test run number

DATE Test date (month, day, year)

ORG Organic emissions in grams-per-mile or grams-per-test (SHED)

HC* Hydrocarbon emissions in grams-per-mile or grams-per-test (SHED)

CO Carbon monoxide emissions in grams-per-mile

CO_2 Carbon dioxide emissions in grams-per-mile

NO_x Nitrogen oxide emissions in grams-per-mile

MPGC Miles-per-gallon fuel economy by carbon balance

MPGV Miles-per-gallon fuel economy by flowmeter

MPBC Energy economy in miles-per-million Btu's calculated from MPGC

MPBV Energy economy in miles-per-million Btu's calculated from MPGV

Ald Aldehyde emissions during FTP in milligrams-per-mile

ET Ethanol emissions in milligrams-per-mile or grams-per-test

ME Methanol emissions in milligrams-per-mile or grams-per-test

---

* HC = ORG - a(ET) - b(ME) - C(Ald)

where:

	Exhaust	Evaporative
a	0.69	0.70
b	0.89	0.72
c	0.73	-

PLEASE NOTE:

The printouts in Appendix B designate the fuels as BASM, MG-1, MG-2, MG-3, MG-4, and MG-5. Elsewhere in this report, the fuels are identified by the general fuel code OxBy, in which x is the nominal percent oxygen and y is the nominal percent isobutanol. Using this system, the fuel codes are as follows:

BASM	=	Base Fuel
MG-1	=	02B1
MG-2	=	02B0
MG-3	=	05B3
MG-4	=	05B0
MG-5	=	08B2

APPENDIX B

TEST DATA

VEHICLE SELECTION PANEL

N. E. Gallopoulos (Leader)	General Motors Research Laboratories
A. M. Bierylo	Chrysler Corporation
H. T. Niles	Ford Motor Company
M. W. Pepper	Exxon Research & Engineering Co.

ANALYTICAL METHODS AND EMISSION TEST PROCEDURES PANEL

H. T. Niles (Leader)	Ford Motor Company
J. H. Baudino	ARCO Petroleum Company
F. Black	U.S. Environmental Protection Agency
N. D. Brinkman	General Motors Research Laboratories
W. S. Fagley	Chrysler Corporation
C. P. Tracy	Amoco Oil Company

CRC ALTERNATIVE AUTOMOTIVE FUELS GROUP

N. E. Gallopoulos (Leader)	General Motors Research Laboratories
A. M. Bierylo	Chrysler Corporation
F. S. Bove	Texaco Inc.
B. C. Davis	Sun Tech, Inc.
E. E. Ecklund	U.S. Department of Energy
T. Ichimiya	Toyota Motor Company
J. C. Ingamells	Chevron Research Company
R. G. Jackson	Continental Oil Company
W. J. Koehl	Mobil Research & Development Corp.
R. M. Matsuo	Union Oil Company of California
G. H. Meguerian	Amoco Oil Company
H. T. Niles	Ford Motor Company
J. Panzer	Exxon Research & Engineering Co.
C. H. Phoebe	Gulf Research & Development Co.
S. P. Thomas	Phillips Petroleum Company
F. L. Voelz	ARCO Petroleum Company

DATA ANALYSIS PANEL

J. C. Ingamells (Leader)	Chevron Research Company
C. E. Baxter	Mobil Research & Development Corp.
B. C. Davis	Sun Tech, Inc.
T. Ichimiya	Toyota Motor Corporation
R. M. Matsuo	Union Oil Company of California
H. T. Niles	Ford Motor Company
J. Panzer	Exxon Research & Engineering Co.
N. D. Brinkman (Advisor)	General Motors Research Laboratories
D. S. Gray (Consultant)	

FUEL SELECTION PANEL

N. D. Brinkman	General Motors Research Laboratories
J. L. Keller	Union Oil Company of California
B. C. Davis	Sun Tech, Inc.
D. S. Gray	Amoco Oil Company
R. E. Hileman	Texaco Inc.
H. T. Niles	Ford Motor Company
J. Panzer	Exxon Research & Engineering Co.

APPENDIX A

MEMBERSHIP: CRC ALTERNATIVE AUTOMOTIVE FUELS GROUP AND PANELS

REFERENCES

1. Coordinating Research Council, Inc., "Performance Evaluation of Alcohol-Gasoline Blends in 1980 Model Automobiles: Phase I - Ethanol-Gasoline Blends," CRC Report No. 527, July 1982.

2. R. E. Pauls and R. W. McCoy, "Gas and Liquid Chromatographic Analysis of Methanol, Ethanol, Tertiary Butyl Alcohol, and Methyl Tertiary Butyl Ether," Journal of Chromatographic Sciences, Volume 19, November 1981, pp. 558-561.

3. I. Jack. Oita, "Automatic Carbon and Hydrogen Determination," Analytical Chemistry, Volume 52, 1980, p. 1007.

4. R. L. Cummins and T. R. Hauser, "Determination of MBTH Colorimetric Aldehydes," Analytical Chemistry, Volume 36, Number 681, 1964.

5. Treasury Ruling ATF-67, Completely Denatured Alcohol Formula #20, 45 Federal Register, p. 20, 420, March 27, 1980.

6. U. S. Code of Federal Regulations, Title 40, Part 86, Subparts A and B for 1980 Model Year Vehicles, Revised July 1980.

7. Robert L. Furey and Jack King, "Evaporative and Exhaust Emissions from Cars Fueled with Gasoline Containing Ethanol or Methanol Tertiary Butyl Ether," SAE Paper No. 800261, February 1980.

8. Coordinating Research Council, Inc., "Driveability Performance of 1977 Passenger Cars at Intermediate Ambient Temperatures - Paso Robles," CRC Report No. 499, September 1978.

9. Coordinating Research Council, Inc., "1966 CRC Vapor Lock Tests," CRC Report No. 420, November 1968.

10. George W. Snedecor and William G. Cochran, Statistical Methods, Iowa State University Press, 1980, p. 234.

REFERENCES

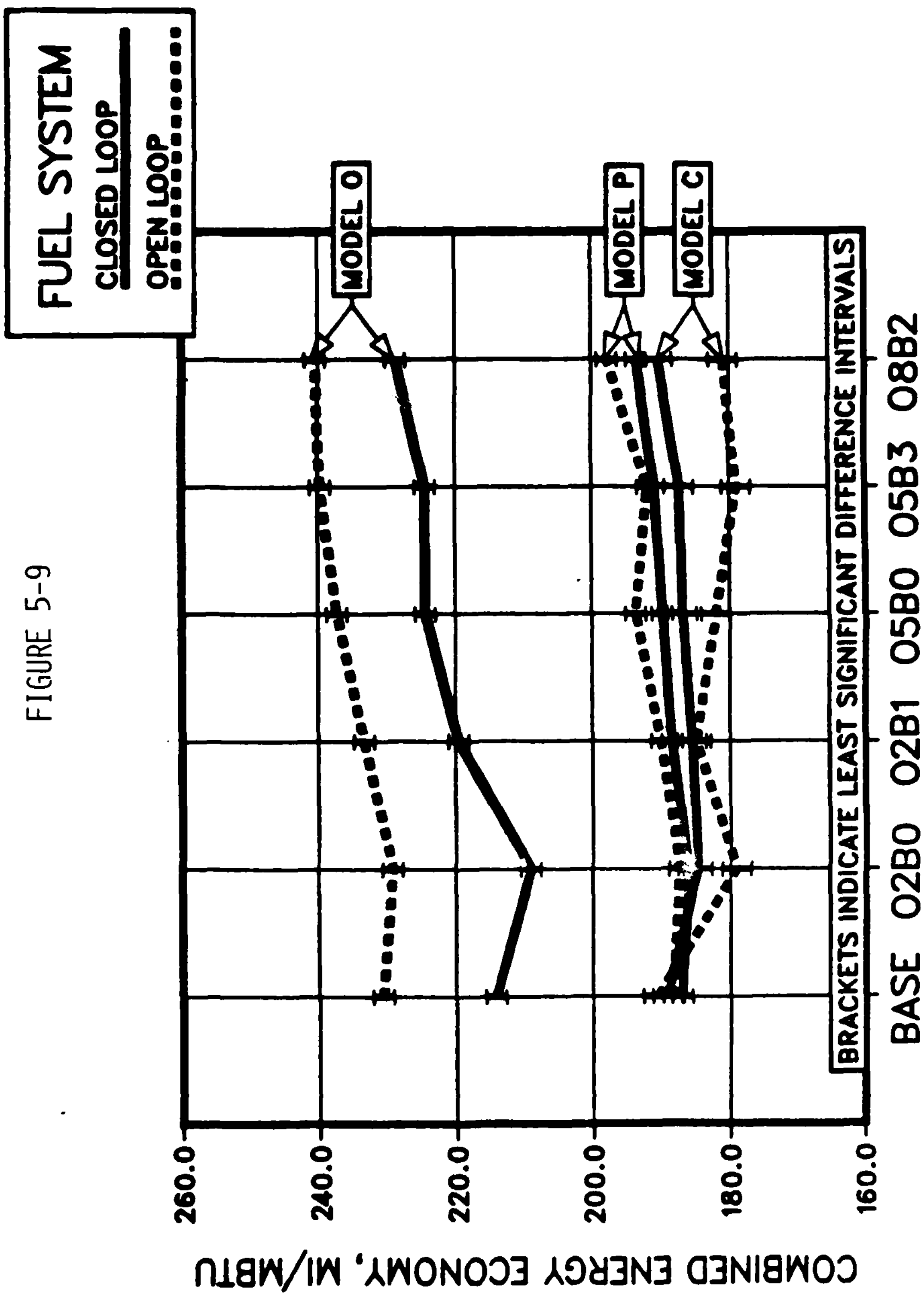

FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL O
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
260.0
240.0
220.0
200.0
180.0
160.0
COMBINED ENERGY ECONOMY, MI/MBTU
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

FIGURE 5-9

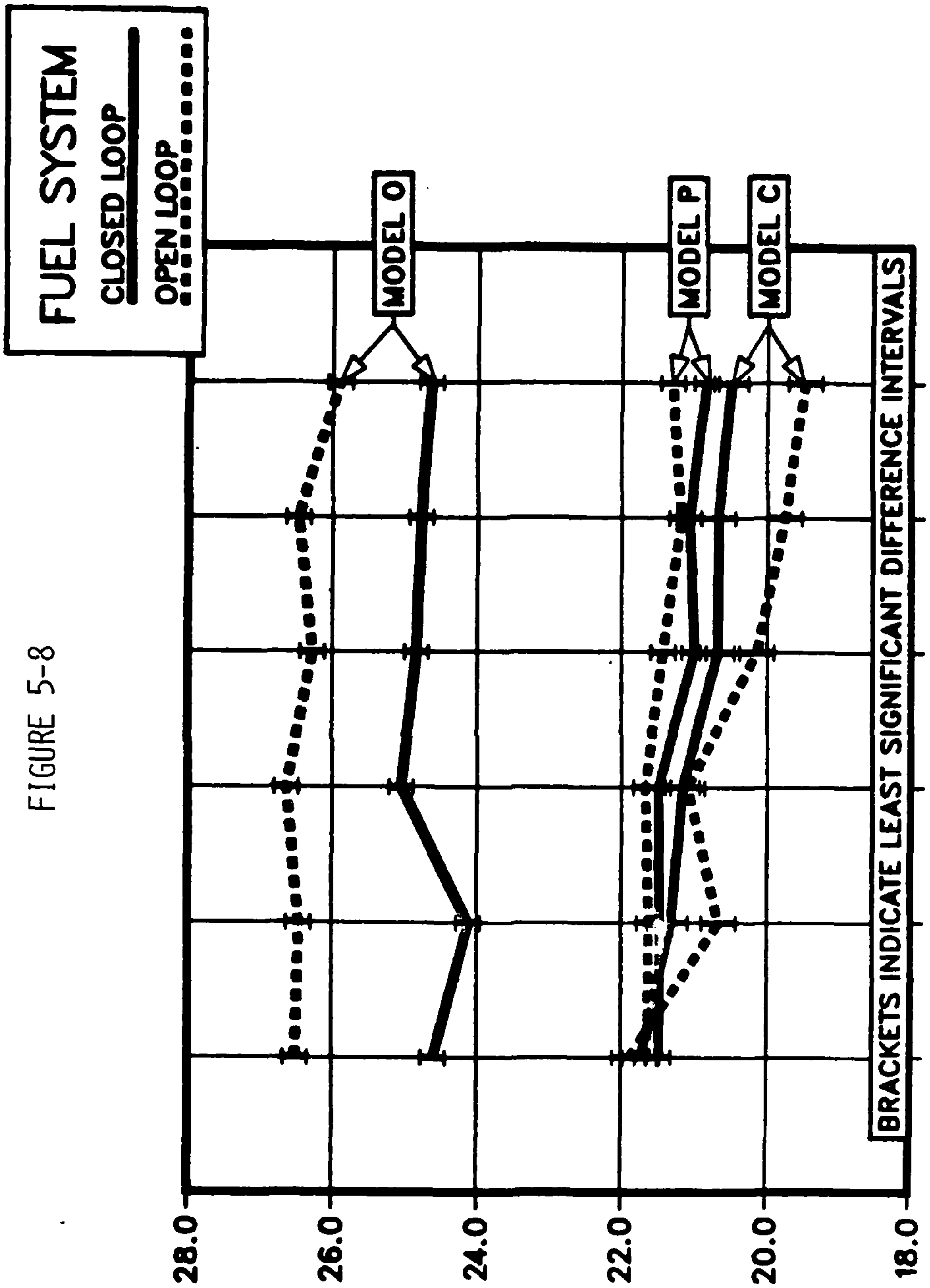

FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL O
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL
28.0
26.0
24.0
22.0
20.0
18.0
COMBINED FUEL ECONOMY, MPG

FIGURE 5-8

Attempts were made to define mathematical relationships between vehicle performance factors and fuel properties by regression analysis. It was not possible, however, to isolate specific fuel properties affecting the performance parameters, because the experiment was not designed for this purpose. Consequently, another experimental program is needed to define the response of vehicle performance factors to fuel characteristics such as oxygen content and volatility, which this program strongly suggests are the two most influential on vehicle performance. Oxygen content affects stoichiometry and, therefore, affects vehicle operation; changes in volatility affect vehicle performance as well.

The results of this study are qualitatively consistent with those of other investigations and of Phase I in which the effect of 10 percent ethanol in gasoline was investigated. Quantitative comparisons between Phase I and Phase II results are not appropriate, because oxygen content, hydrocarbon composition, vapor pressure, and distillation characteristics of the test fuels were not matched between the two phases.

5.4.9 Vapor Lock

Due to the limitations of the test design, i.e., testing a limited range of fuel volatilities at only 100°F, none of the cars showed vapor lock on these fuels.

5.4.10 Fuel and Energy Economy

Fuel and energy economy are discussed in terms of combined highway and city FTP in this section. For additional separate information regarding highway and FTP fuel and energy economy, refer to Appendix H. Because trends are not uniform among vehicles, each model fuel system is discussed individually.

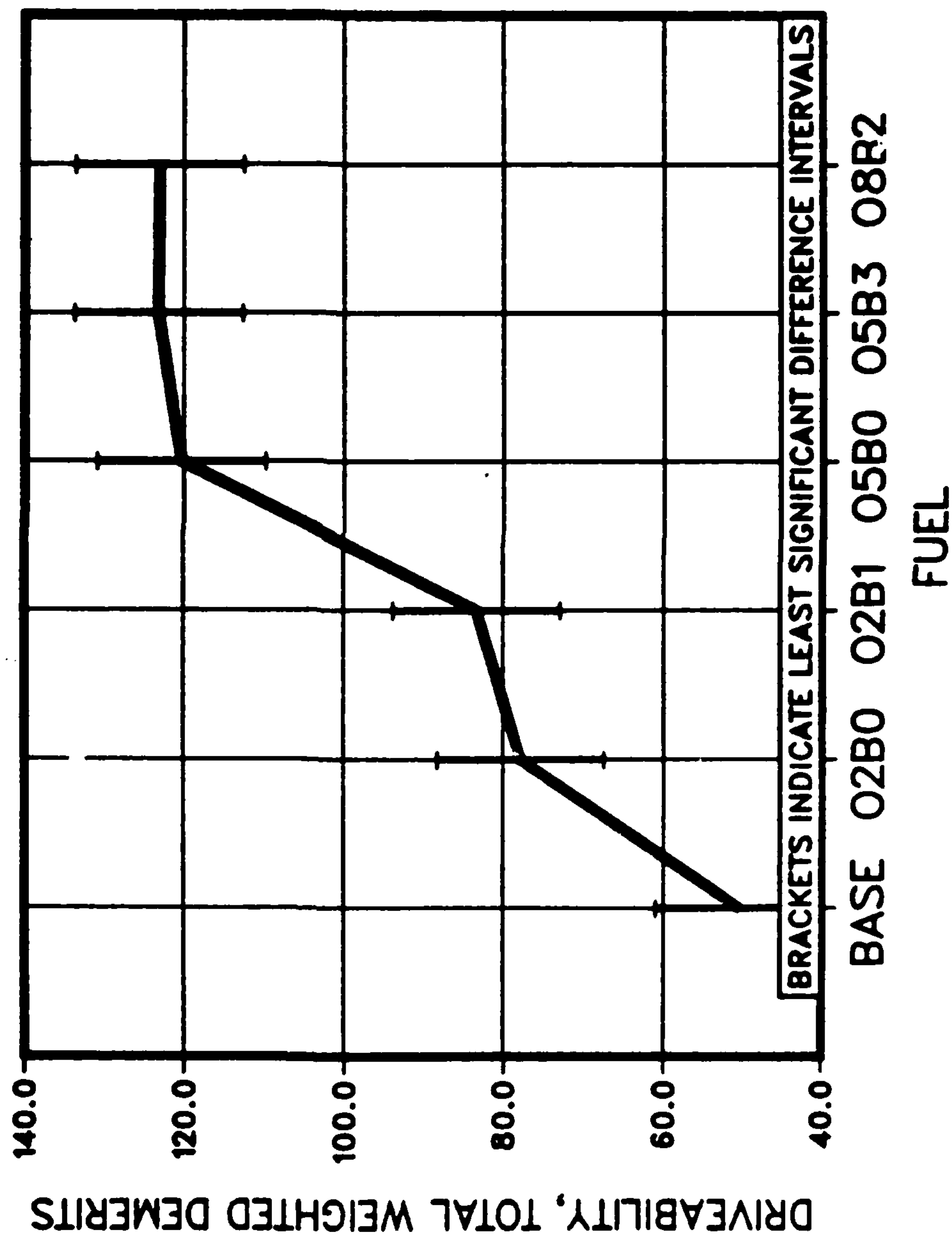
With few exceptions, the confidence intervals of adjacent oxygen concentrations overlap; therefore, no general trend of fuel economy versus alcohol content was found, because the three car models behaved differently. As shown in Figure 5-8, however, as the oxygen level of the fuel increased, the number of cars that showed significant reductions in fuel economy versus the base fuel increased. For example, in all but the closed-loop Model O, fuel economy with Fuel 08B2 was significantly lower than that with the base fuel. Also, this effect was strongest with Model C. Further, comparing Fuel 05B3 with the base fuel showed statistically significant reductions in fuel economy with all but Model O. Co-solvent effects were not significant. Differences in heating value among the three base fuels may also have influenced the fuel economy results.

As indicated in Figure 5-9 and Table 5-3, because the fuel economy changes did not correspond with fuel energy content changes, there were energy economy increases in Models O and P at higher oxygen levels.

5.5 IMPLICATIONS AND NEED FOR ADDITIONAL STUDY

The results of this experiment and the analysis of variance are not sufficient to construct mathematical relationships between various vehicle performance factors and specific fuel properties or compositions. Despite this limitation, and the fact that not all cars responded alike to the blending of alcohol in the fuel, the study showed that the presence of alcohol in gasoline affected all vehicle performance factors, except for vapor lock and aldehydes. The lack of alcohol effect on these two variates was likely the result of experimental problems.

FIGURE 5-7



BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
140.0
120.0
100.0
80.0
60.0
40.0
DRIVEABILITY, TOTAL WEIGHTED DEMERITS
BASE
02B0
02B1
05B0
05B3
08B2
FUEL

TABLE B-2. INDIVIDUAL TEST DATA (Continued)

					FTP									HFET									DIURNAL				HOT SOAK					FTP	
CAR	TF	ODO	RUN	DATE	ORG	HC	CO	CO_2	NO_x	MPGC	MPGV	MPBC	MPBV	ORG	HC	CO	CO_2	NO_x	MPGC	MPGV	MPBC	MPBV	ORG	HC	ET	ME	ORG	HC	ET	ME	ALD	ET	ME
06-1	3 5	12679	5636.6	52881	0.319	0.296	5.506	440.9	1.027	19.682	19.126	177.66	172.64	0.042	0.042	0.020	323.0	1.762	27.443	25.592	247.72	231.01	1.906	1.903	-11.0	15.1	2.051	2.051	0.0	0.0	33.3	2.2	-3.10
	4 5	12725	5697.0	61181	0.338	0.322	5.595	445.4	1.233	19.479	19.164	175.82	172.98	0.048	0.048	0.034	333.4	1.172	26.584	24.558	239.96	221.67	1.244	1.257	-11.1	-7.8	2.070	2.065	-0.2	7.3	26.4	0.0	-3.60
	5 5	12750	5787.1	61981	0.395	0.376	5.551	473.3	1.759	18.350	18.945	165.64	171.01	0.045	0.045	0.018	345.1	1.687	25.685	25.495	231.85	230.13	0.678	0.693	-22.0	-0.1	1.913	1.884	10.7	29.6	24.6	0.0	1.10
	1 6	12756	5834.1	62681	0.328	0.298	5.163	477.2	2.070	18.048	18.866	157.25	164.37	0.039	0.039	0.027	349.3	1.764	25.118	24.836	218.85	216.39	2.143	2.015	10.9	166.8	2.221	1.977	10.6	325.4	26.2	0.0	12.60
	2 6	12770	5885.9	70181	0.357	0.327	5.635	470.6	1.790	18.262	18.996	159.11	165.51	0.038	0.038	0.017	351.3	1.517	24.976	24.999	217.61	217.81	1.155	1.048	-11.1	159.5	2.738	2.391	21.4	461.2	19.1	0.0	17.90
	1 7	13111	7554.2	120281	0.328	0.294	5.152	472.9	1.594	18.223	18.743	157.92	164.48	0.035	0.035	-0.007	340.3	1.423	25.807	22.693	226.47	199.14	2.507	2.184	66.3	384.4	3.384	2.916	10.7	639.5	15.1	0.4	25.70
	2 7	24052	7619.3	120381	0.426	0.390	5.809	467.3	1.557	18.384	18.670	161.33	163.84	0.035	0.035	0.001	334.1	1.281	26.286	22.823	230.68	200.28	2.538	2.303	11.0	315.1	3.648	3.095	21.3	747.0	33.8	0.8	11.70
	3 7	13153	7767.8	122281	0.403	0.364	5.452	465.8	1.531	18.469	18.899	162.07	165.85	0.030	0.030	-0.005	336.8	1.257	26.073	22.427	228.80	196.81	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	39.3	1.2	11.00
	1 8	12783	5973.6	70981	0.453	0.394	4.071	481.5	1.702	17.246	17.801	148.57	153.35	0.042	0.042	0.025	354.2	1.259	23.815	23.494	205.16	202.39	1.263	1.094	21.9	213.7	2.873	2.312	21.4	759.0	25.7	0.0	45.10
	2 8	12807	6025.0	71681	0.378	0.332	4.783	482.8	1.634	17.171	17.567	147.92	151.33	0.037	0.037	-0.002	356.9	1.247	23.643	23.451	203.67	202.02	1.367	1.096	21.7	355.5	2.848	2.296	21.3	746.6	36.5	0.0	21.70
	1 9	13156	7813.5	122381	0.388	0.342	5.170	463.3	1.399	17.878	17.973	152.36	163.40	0.035	0.035	-0.007	337.0	0.991	25.070	21.645	227.67	196.57	1.981	1.692	10.9	390.6	4.062	3.708	-11.0	502.1	37.8	0.8	19.70
	2 9	13160	7859.8	122981	0.344	0.303	4.248	462.4	1.367	17.975	18.166	163.24	164.98	0.037	0.037	-0.005	335.0	1.022	25.215	21.812	228.99	198.09	1.418	1.192	-0.1	313.4	3.802	2.973	-0.3	1151.5	42.3	0.4	11.50
	110	13164	7875.5	123081	0.394	0.356	5.209	470.7	1.279	17.340	17.352	156.50	156.61	0.051	0.051	-0.003	347.7	0.764	23.937	21.160	216.05	191.17	1.682	1.451	-11.2	331.1	3.244	2.543	-22.1	995.5	32.5	1.5	14.90
	410	24084	7943.0	123181	0.371	0.307	3.573	464.2	1.427	17.679	17.308	159.57	156.22	0.037	0.037	-0.003	339.0	0.813	24.556	21.247	221.63	191.77	1.402	1.181	22.2	285.3	3.295	3.004	-11 2	414.7	42.4	0.4	36.70
04-3	1 5	23826	6097.6	20981	0.149	0.150	3.455	484.2	0.916	18.095	18.116	163.34	163.52	0.027	0.027	0.089	338.8	1.532	26.157	25.684	236.11	231.84	2.289	2.278	0.0	15.2	2.452	2.452	-0.1	-0.2	3.8	0.0	-3.80
	2 5	23840	6154.9	21281	0.199	0.191	3.070	465.9	0.943	18.817	18.467	167.85	166.69	0.029	0.029	0.056	337.2	1.635	26.287	25.499	237.28	230.17	0.497	0.505	0.0	-7.7	2.391	2.378	10.8	7.3	9.8	0.0	1.30
	5 5	12874	6295.9	80791	0.182	0.156	3.419	490.0	0.561	17.881	17.929	161.40	161.84	0.032	0.032	0.281	352.2	1.118	25.145	25.586	226.97	230.95	0.360	0.349	0.0	15.0	2.381	2.247	0.0	186.0	33.9	0.0	1.10
	1 6	12891	6381.5	81481	0.146	0.134	1.349	465.8	0.905	18.740	19.823	163.27	164.00	0.031	0.031	0.051	345.5	1.298	25.394	25.956	221.25	226.15	1.325	1.226	-0.1	137.6	3.933	3.631	10.9	408.4	13.6	0.0	2.50
	2 6	12895	6456.6	81881	0.140	0.126	1.710	478.5	1.107	18.225	18.334	158.79	159.74	0.031	0.031	0.019	345.3	1.747	25.411	26.424	221.40	230.22	1.598	1.450	-0.1	205.4	4.731	4.019	10.6	978.3	12.3	0.0	5.60
	1 7	13016	6600.4	102381	0.212	0.200	2.726	438.5	0.991	17.803	18.810	156.23	165.07	0.030	0.030	0.027	339.6	1.542	25.858	26.567	226.92	233.14	1.007	0.875	0.0	184.0	2.718	2.342	10.8	511.9	14.1	0.0	2.20
	2 7	13022	6662.3	102781	0.180	0.163	2.622	475.4	0.688	18.299	18.470	160.58	162.08	0.029	0.029	0.053	329.9	0.918	26.616	26.952	233.57	236.52	1.093	1.005	0.0	122.4	3.323	2.865	43.3	594.3	17.3	0.0	4.60
	1 8	12900	6508.3	82981	0.135	0.133	1.330	466.7	1.096	17.986	18.299	154.94	157.64	0.031	0.031	0.004	335.0	1.547	25.188	25.667	216.98	221.11	1.380	1.238	-0.1	197.5	5.075	4.637	-0.2	608.3	0.8	0.0	1.40
	2 8	12903	6557.1	82581	0.160	0.160	1.959	467.5	1.430	17.915	18.178	154.33	156.59	0.034	0.034	0.000	328.4	2.271	25.691	25.746	221.32	221.79	1.155	0.997	-0.1	219.7	4.044	3.504	10.6	740.3	23.3	0.0	3.20
	1 9	13026	6713.9	102981	0.213	0.202	2.069	458.5	0.858	18.274	18.510	165.95	168.10	0.038	0.038	0.006	347.3	2.027	24.323	26.086	220.89	236.90	1.444	1.240	0.0	283.1	7.336	6.150	21.6	1626.5	4.6	0.0	8.80
	2 9	13046	6853.2	110581	0.339	0.310	1.828	456.3	1.232	18.359	18.427	166.73	167.35	0.034	0.034	0.012	322.4	1.971	26.198	26.912	237.92	244.40	1.519	1.354	0.0	229.8	6.833	5.792	21.5	1425.4	2.8	0.0	30.00
	110	24020	6774.3	110381	0.251	0.228	2.178	445.4	1.571	18.517	18.331	167.13	165.45	0.031	0.031	0.010	324.7	1.894	25.633	25.881	231.35	233.57	1.225	1.106	-11.1	175.5	5.439	4.656	32.3	1055.6	16.8	0.0	12.50
	210	13043	6810.2	110481	0.276	0.242	1.509	450.3	1.549	18.358	18.089	165.67	163.27	0.032	0.032	0.018	324.7	1.839	25.632	25.841	231.34	233.23	1.418	1.226	0.0	266.9	5.679	4.529	32.2	1565.6	21.4	0.4	20.20
04-4	1 5	23822	6160.0	20581	0.153	0.149	1.134	470.0	1.492	18.780	19.907	169.52	179.69	0.043	0.043	0.075	332.6	2.460	26.646	27.104	240.52	244.66	0.903	0.903	0.0	0.0	2.678	2.678	0.0	0.0	5.6	0.0	0.00
	2 5	23337	6224.8	21281	0.281	0.276	2.939	469.5	1.363	18.671	19.791	168.54	178.64	0.041	0.041	0.096	329.9	2.310	26.860	27.327	242.45	246.67	0.973	0.973	0.0	-0.1	2.458	2.455	-11.0	14.9	9.9	1.0	-2.90
	1 6	13613	6391.0	72081	0.160	0.135	1.107	464.8	1.719	18.794	19.247	163.75	167.69	0.038	0.038	0.022	329.7	2.384	26.606	26.994	231.81	235.19	1.052	0.822	-0.1	320.2	2.788	2.270	64.3	657.6	33.5	0.0	1.10
	2 6	13829	6437.4	72381	0.136	0.123	0.783	463.2	1.336	18.881	19.343	164.51	168.53	0.037	0.037	0.012	332.8	1.823	26.362	26.994	229.69	235.19	1.054	0.890	0.0	227.7	3.141	2.837	21.4	401.7	15.6	0.0	1.40
	1 7	13123	7811.8	10782	0.206	0.189	1.206	465.7	2.049	18.708	20.008	164.18	175.58	0.086	0.086	0.009	327.0	2.563	26.867	26.848	235.78	235.61	1.319	1.247	-0.2	100.4	3.254	2.988	21.5	348.2	19.2	0.0	2.90
	2 7	13177	7870.0	10882	0.120	0.095	1.755	466.3	1.855	18.714	19.566	164.23	171.70	0.052	0.052	0.011	320.8	2.398	27.382	26.997	240.29	236.91	0.886	0.886	0.0	0.2	2.897	2.897	0.0	0.2	25.6	0.0	7.50
	1 8	12832	6469.7	72481	0.129	0.118	0.418	453.9	1.493	18.551	18.767	159.81	163.39	0.033	0.033	0.006	325.9	1.582	25.890	26.261	223.03	226.22	1.080	0.954	-0.1	174.7	3.747	3.238	-0.2	707.4	14.2	0.0	0.50
	2 8	12840	6539.9	72781	0.138	0.117	0.591	449.3	1.457	18.728	19.133	161.33	164.82	0.034	0.034	0.005	324.2	1.615	26.024	26.276	224.18	226.35	1.077	0.940	-0.1	190.3	3.360	2.917	10.6	604.4	19.3	0.0	7.60
	1 9	12970	6638.0	93081	0.275	0.263	1.159	443.0	2.016	18.959	18.761	172.18	170.38	0.033	0.033	0.018	321.7	2.134	26.260	26.707	238.48	242.54	0.632	0.495	-0.1	189.9	2.911	2.523	-0.1	539.3	16.9	0.0	-0.20
	2 9	13179	7920.0	11282	0.196	0.179	0.693	449.8	1.737	18.735	18.501	170.15	168.02	0.031	0.031	0.006	326.5	2.261	25.993	26.440	236.06	240.12	1.266	1.266	0.0	0.3	3.688	3.687	0.0	0.8	17.5	0.0	4.30
	110	13168	6685.0	10582	0.162	0.149	0.874	446.0	1.980	18.670	19.106	168.51	172.45	0.034	0.034	-0.003	320.3	1.777	25.990	25.862	234.58	233.42	1.206	1.096	-0.1	152.8	2.893	2.557	-0.2	466.6	13.6	0.7	3.20
	210	13171	7753.9	10682	0.076	0.085	0.148	445.9	1.781	18.263	18.962	164.84	171.15	0.034	0.034	-0.003	318.5	1.775	26.141	26.049	235.94	235.11	1.276	1.103	11.0	229.7	9.738	8.379	21.4	1866.0	14.6	0.0	0.50
C4-3	1 5	12882	7226.3	81281	0.505	0.498	3.362	466.4	0.478	18.432	18.891	166.38	170.52	0.137	0.137	0.320	339.7	0.395	26.033	26.544	234.99	239.60	1.792	1.754	-0.1	53.3	1.128	1.115	10.5	7.2	6.1	0.0	2.90
	2 5	12899	7287.4	81981	0.505	0.499	8.166	453.3	0.588	18.963	19.034	171.15	171.81	0.077	0.077	0.177	329.3	0.443	26.889	27.021	242.71	243.91	2.099	2.094	-0.1	7.4	3.123	3.125	-10.9	7.3	8.4	0.2	-2.30
	1 6	12921	7357.8	90281	0.501	0.486	7.593	451.2	0.632	18.489	18.867	161.09	164.38	0.060	0.060	0.071	336.6	0.522	26.056	26.383	227.01	229.87	1.634	1.445	24.8	237.9	5.078	4.747	21.4	438.5	14.4	0.0	4.80
	3 6	13110	8135.0	120281	0.322	0.308	4.190	460.1	0.691	18.768	19.286	163.52	168.03	0.069	0.069	0.063	327.5	0.525	26.776	27.012	233.30	235.35	1.754	1.583	0.0	237.2	4.285	4.016	21.6	352.3	14.9	0.8	3.20
	1 7	13065	7921.0	111291	0.378	0.361	5.400	464.7	0.706	18.829	19.319	165.24	169.53	0.074	0.074	0.073	333.7	0.487	26.293	26.791	230.74	235.11	2.091	1.876	-0.1	299.3	4.957	4.174	10.7	1077.3	11.0	0.0	9.60
	2 7	13084	7966.9	111981	0.338	0.328	5.470	456.3	0.628	18.851	19.156	165.43	168.10	0.068	0.068	0.062	322.9	0.462	27.175	27.176	238.48	238.48	1.719	1.542	-0.1	245.7	4.907	4.692	21.6	278.1	10.0	0.0	3.20
	2 8	12988	7546.7	100981	0.520	0.509	4.142	447.4	0.833	18.526	19.148	159.59	164.95	0.059	0.059	0.054	323.6	0.610	26.061	26.168	224.50	225.42	1.564	1.348	10.9	289.8	11.932	10.243	43.0	2304.1	8.8	0.0	5.30
	3 8	24048	8172.0	120381	0.407	0.397	3.790	446.5	0.661	18.601	19.160	160.23	165.05	0.068	0.068	0.059	321.3	0.502	26.244	26.032	226.08	224.25	1.867	1.652	0.0	299.0	19.733	9.499	21.6	1970.5	4.3	0.4	7.30
	1 9	13097	8009.2	112481	0.342	0.329	4.245	460.2	0.719	18.057	18.498	163.98	167.99	0.062	0.062	0.055	333.4	0.501	25.325	25.926	229.99	235.45	1.874	1.627	-0.1	343.4	18.729	15.629	43.1	4263.4	7.2	0.4	8.50
	2 9	13106	8078.4	120181	0.504	0.477	6.065	449.4	0.760	18.349	18.989	156.64	172.45	0.071	0.071	0.055	328.0	0.535	25.743	26.098	233.78	237.01	1.914	1.634	-0.1	387.2	14.989	12.184	43.2	3854.0	23.7	0.4	10.50
	110	12996	7575.7	101481	0.357	0.337	2.202	444.8	0.733	18.527	19.124	167.22	172.61	0.045	0.045	0.029	338.2	0.485	24.609	25.362	222.12	228.91	2.109	1.827	0.0	391.4	17.578	13.377	43.2	5792.4	13.5	0.0	10.90
	210	13002	7643.2	101681	0.431	0.412	2.400	456.2	0.725	18.050	18.497	162.91	166.95	0.045	0.045	0.029	327.9	0.513	25.377	25.701	229.05	231.97	2.377	2.027	11.0	476.1	17.214	12.974	86.3	5804.9	12.0	0.0	11.70
C4-4	1 5	12887	6172.8	81381	0.372	0.372	3.067	480.4	0.644	18.233	18.714	164.58	168.92	0.059	0.059	0.063	343.3	0.373	25.816	26.065	233.02	235.46	1.090	1.079	0.0	15.2	2.597	2.579	10.7	14.7	21.3	0.0	5.20
	2 5	12997	6272.2	81891	0.343	0.329	2.746	477.1	0.756	18.379	18.833	165.90	170.00	0.079	0.079	0.239	340.6	0.318	25.991	25.661	234.61	231.63	1.235	1.235	0.0	-0.1	2.648	2.638	-0.1	14.6	16.6	0.0	2.10
	1 6	12717	6369.3	90181	0.265	0.238	1.810	481.1	0.858	18.105	18.565	157.74	161.75	0.050	0.050	0.044	344.2	0.432	25.485	25.911	222.04	225.76	1.411	1.318	0.0	129.6	3.332	3.089	10.7	327.5	29.2	0.0	6.90
	2 6	12943	6418.6	91581	0.317	0.300	2.355	475.7	0.781	18.270	18.647	159.18	162.47	0.044	0.044	0.061	344.7	0.451	25.442	25.765	221.67	224.48	1.368	1.226	-0.1	197.0	3.515	3.161	-0.1	492.4	10.3	0.0	10.80
	1 7	13000	6793.5	101581	0.315	0.307	2.559	484.6	0.978	17.940	18.495	157.44	162.30	0.057	0.057	0.056	342.3	0.560	25.643	26.324	225.03	231.01	1.700	1.496	0.0	283.6	3.203	2.895	-0.1	427.9	9.4	0.0	0.90
	2 7	24002	6845.4	101981	0.299	0.284	2.159	473.2	0.774	18.374	18.821	161.41	165.16	0.065	0.065	0.080	338.3	0.469	25.942	25.849	227.66	226.84	1.779	1.581	-0.1	275.2	2.981	2.689	-0.1	405.4	19.0	0.0	1.50
	1 8	12947	6468.3	91881	0.289	0.275	1.732	467.9	0.808	17.899	18.212	154.19	156.89	0.047	0.047	0.048	339.9	0.489	24.814	25.108	213.76	216.29	1.471	1.280	-0.7	265.7	4.108	3.587	21.5	703.1	12.3	0.0	5.60
	2 8	12961	6532.2	92481	0.292	0.254	1.616	470.2	0.623	17.820	18.034	153.51	155.35	0.051	0.051	0.048	338.4	0.340	24.926	25.261	214.72	217.78	1.396	1.187	0.0	290.9	3.514	2.874	10.8	878.0	12.5	0.0	32.90
	1 9	12968	6587.3	92981	0.224	0.191	1.477	477.5	0.654	17.585	17.781	157.70	163.29	0.035	0.035	0.035	335.6	0.490	25.168	25.343	228.56	230.15	1.822	1.394	0.0	593.9	3.893	3.534	21.5	477.1	22.0	0.0	18.70
	2 9	12974	6645.6	100281	0.244	0.213	2.047	463.1	0.918	18.093	18.448	164.31	167.54	0.038	0.038	0.036	341.8	0.471	24.709	25.383	224.39	230.52	2.011	1.681	-0.1	458.8	5.509	4.741	10.6	1056.0	4.9	0.0	31.00
	110	12785	6638.3	100881	0.238	0.208	1.742	464.9	0.906	17.775	18.037	160.43	162.80	0.023	0.023	0.016	334.3	0.503	24.903	25.009	224.77	225.72	1.633	1.398	0.0	326.8	4.093	3.505	10.7	806.6	16.0	0.0	21.00
	210	12992	6742.2	101381	0.177	0.163	1.261	463.6	1.173	17.864	18.031	161.24	162.74	0.033	0.033	0.027	332.4	0.526	25.041	24.653	226.01	222.51	1.686	1.320	11.0	497.8	3.826	3.229	10.7	818.3	1.5	0.0	14.00

TABLE B-3. DEFINITION OF SYMBOLS FOR TABLES B-4 THROUGH B-9

CAR	**CODE**	Alphanumeric code defined in Table B-1
FTP	**ORG-FID**	Organic exhaust emissions in grams-per-mile
FTP	**HC**	Hydrocarbon exhaust emissions in grams-per-mile
FTP	**CO**	Carbon monoxide exhaust emissions in grams-per-mile
FTP	**NO_x**	Oxides of nitrogen exhaust emissions in grams-per-mile
FTP	**MEOH**	Methanol exhaust emissions in milligrams-per-mile
FTP	**ALD**	Aldehyde exhaust emissions in milligrams-per-mile
SHED	**ORG-FID**	Organic evaporative emissions in grams
SHED	**HC**	Hydrocarbon evaporative emissions in grams
FTP	**MPGC**	FTP carbon-balance fuel economy in miles-per-gallon
FTP	**MPGV**	FTP Fluidyne fuel economy in miles-per-gallon
FTP	**MPGA**	Average FTP fuel economy in miles-per-gallon
HFET	**MPGC**	HFET carbon-balance fuel economy in miles-per-gallon
HFET	**MPGV**	HFET Fluidyne fuel economy in miles-per-gallon
HFET	**MPGA**	Average HFET fuel economy in miles-per-gallon
DRIVEABILITY		Driveability total weighted demerits
VAPOR	**LOCK**	Vapor lock percent increase in critical acceleration time
FTP	**MPBC**	FTP carbon-balance energy economy in miles-per-million Btu's
FTP	**MPBV**	FTP Fluidyne energy economy in miles-per-million Btu's
FTP	**MBPA**	Average FTP energy economy in miles-per-million Btu's
HFET	**MPBC**	HFET carbon-balance energy economy in miles-per-million Btu's
HFET	**MPBV**	HFET Fluidyne energy economy in miles-per-million Btu's
HFET	**MPBA**	Average HFET fuel economy in miles-per-million Btu's

MEANS

TABLE B-4. CAR/FUEL AVERAGE DATA

CAR CODE	FUEL	FTP ORG	FTP HC	FTP CO	FTP NOX-C	FTP ALD	FTP ME-OH	SHED ORG	SHED HC	SHED ME-OH	FTP MPGC	FTP MPGV	FTP MPGA	HFET MPGC	HFET MPGV	HFET MPGA	MEAN MPGA	DRIVE-ABILITY	VAPOR LOCK	FTP MPBC	FTP MPBV	FTP MPBA	HFET MPBC	HFET MPBV	HFET MPBA	MEAN MPBA
04-1	BASM	0.185	0.174	2.034	1.638	14.20	0.55	1.466	1.314	0.201	24.56	23.05	23.78	32.89	32.91	32.90	27.89	75.0	-4.8	214.0	200.9	207.2	286.5	286.7	286.6	213.0
	MG-1	0.151	0.143	1.433	1.844	11.20	0.40	1.834	1.612	0.292	23.77	23.38	23.57	33.21	33.19	33.20	27.91	112.0	-1.9	208.6	205.2	206.9	291.4	291.2	291.3	244.9
	MG-2	0.196	0.185	1.591	1.771	12.75	1.40	2.580	2.287	0.403	24.21	23.40	23.80	32.62	32.82	32.72	27.81	115.0	-3.0	208.5	201.6	205.0	281.0	282.7	281.8	239.6
	MG-3	0.155	0.143	1.012	2.188	12.80	3.10	3.177	2.732	0.613	24.15	23.48	23.81	32.80	33.03	32.91	27.91	204.0	-5.0	219.4	213.3	216.3	297.9	299.9	298.9	253.5
	MG-4	0.177	0.161	1.868	2.075	12.10	5.85	2.752	2.345	0.547	23.35	23.09	23.22	32.26	32.68	32.47	27.39	170.5	-4.0	210.8	208.4	209.6	291.2	295.0	293.1	247.2
	MG-5	0.183	0.166	1.802	1.977	18.35	5.00	2.826	2.356	0.639	23.24	23.00	23.12	32.37	32.52	32.44	27.32	168.0	-4.4	215.8	213.5	214.7	300.5	301.9	301.2	253.6
04-2	BASM	0.270	0.263	3.404	1.209	9.05	0.50	1.695	1.462	0.045	22.79	22.70	22.75	30.57	31.13	30.85	26.39	49.0	-3.5	198.6	197.8	198.2	266.3	271.3	268.8	230.0
	MG-1	0.182	0.159	2.657	1.358	22.15	8.50	1.875	1.695	0.245	22.81	22.34	22.57	31.13	31.74	31.43	26.56	83.5	1.0	200.2	196.1	198.1	273.1	278.5	275.8	233.1
	MG-2	0.235	0.218	2.984	1.071	16.60	5.45	2.216	1.974	0.363	22.81	22.57	22.69	31.13	31.91	31.52	26.66	79.5	-2.5	196.5	194.4	195.5	268.2	274.9	271.5	229.7
	MG-3	0.316	0.291	2.685	1.894	22.20	10.00	2.121	1.837	0.401	22.51	22.26	22.38	31.57	31.50	31.54	26.50	89.5	-4.4	204.4	202.1	203.3	286.7	286.1	286.4	240.7
	MG-4	0.290	0.265	2.999	1.910	24.80	8.05	2.145	1.928	0.286	22.78	22.29	22.53	30.85	31.09	30.97	26.33	100.0	-5.0	205.6	201.1	203.4	278.4	280.6	279.5	237.6
	MG-5	0.253	0.238	2.557	2.102	14.95	4.85	2.339	1.917	0.561	21.77	22.23	22.00	29.89	30.88	30.38	25.77	84.5	-1.5	202.1	206.4	204.2	277.5	286.7	282.0	239.2
C4-1	BASM	0.370	0.348	6.956	0.756	23.55	4.75	3.168	3.111	0.079	21.51	22.03	21.76	32.41	34.47	33.51	27.06	86.0	-1.3	187.4	191.9	189.6	284.1	300.3	292.0	235.8
	MG-1	0.275	0.260	3.087	0.803	13.30	6.80	6.824	6.334	0.400	21.81	21.64	21.72	33.41	34.29	33.84	27.18	120.0	2.2	191.4	189.9	190.6	293.2	300.9	297.0	238.5
	MG-2	0.300	0.287	4.176	0.774	8.40	8.40	6.377	5.206	1.626	21.12	20.08	20.59	31.25	33.02	32.12	25.78	116.5	-2.6	181.9	173.0	177.3	269.2	284.5	276.7	222.0
	MG-3	0.254	0.248	2.864	1.176	4.90	2.85	7.517	8.109	1.941	21.30	21.13	21.22	32.57	33.38	32.97	26.51	180.0	-2.7	193.5	191.9	192.7	295.8	303.2	299.4	240.7
	MG-4	0.329	0.306	3.574	1.015	24.25	6.25	11.796	9.712	2.863	21.22	21.09	21.15	32.82	33.58	33.20	26.57	122.0	3.7	191.5	190.3	190.9	296.2	303.1	299.6	239.8
	MG-5	0.372	0.349	3.356	0.899	8.30	19.25	9.554	8.013	2.104	20.99	21.13	21.06	32.62	33.13	32.87	26.38	205.0	2.7	194.9	196.2	195.5	302.9	307.6	305.2	244.9
C4-2	BASM	0.399	0.377	4.280	0.567	28.60	1.60	2.341	2.328	0.019	21.15	21.18	21.17	28.80	30.27	29.52	24.92	75.5	-3.0	184.3	184.5	184.4	250.9	263.7	257.2	217.1
	MG-1	0.309	0.282	4.404	0.575	26.95	7.75	4.258	3.847	0.351	20.89	21.63	21.25	27.33	29.83	28.52	24.53	81.0	-2.9	183.3	189.8	186.5	239.8	261.7	250.3	215.2
	MG-2	0.317	0.298	3.672	0.675	12.10	11.35	4.767	4.064	0.955	21.04	20.91	20.98	27.25	30.21	28.65	24.43	90.0	-2.5	181.3	180.1	180.7	234.7	260.2	246.8	210.4
	MG-3	0.300	0.277	2.648	0.603	21.95	7.95	5.166	4.215	1.310	20.97	21.36	21.17	29.09	30.34	29.70	25.01	108.5	-4.9	190.5	194.0	192.2	264.2	275.5	269.7	227.1
	MG-4	0.441	0.412	3.558	0.628	10.70	24.75	4.618	3.675	1.289	20.95	21.29	21.12	28.63	30.34	29.46	24.87	91.5	-2.5	189.1	192.1	190.6	258.4	273.8	265.9	224.5
	MG-5	0.325	0.303	3.075	0.798	11.15	15.70	8.145	6.744	1.915	20.67	20.71	20.69	29.44	30.57	30.00	24.88	103.0	-0.5	191.9	192.3	192.1	273.4	283.9	278.5	231.0
C6-1	BASM	0.350	0.326	6.956	0.645	35.30	-1.73	2.317	2.272	0.052	19.31	19.20	19.25	26.20	24.88	25.52	22.08	44.5	-19.8	168.2	167.3	167.7	228.3	216.8	222.4	192.3
	MG-1	0.291	0.254	4.529	0.863	17.60	27.00	2.677	2.393	0.384	18.23	18.82	18.52	25.45	25.07	25.25	21.55	85.5	-10.6	160.0	165.2	162.5	223.3	220.0	221.6	189.1
	MG-2	0.402	0.385	8.214	0.848	14.50	5.35	3.588	3.157	0.578	18.95	19.28	19.11	25.96	24.11	25.00	21.77	84.5	-9.1	163.2	166.1	164.7	223.6	207.7	215.4	187.5
	MG-3	0.325	0.294	4.191	0.959	22.17	16.47	3.731	3.080	0.883	17.85	18.37	48.10	24.67	24.81	24.74	21.09	111.5	-19.2	162.1	166.8	164.4	224.1	225.3	224.7	191.5
	MG-4	0.362	0.314	6.729	0.907	33.15	24.70	4.136	3.359	1.080	18.16	18.84	18.49	25.03	22.89	23.91	20.93	69.0	-9.9	163.9	170.1	166.9	225.9	206.6	215.8	188.9
	MG-5	0.308	0.266	4.474	0.928	34.95	18.20	4.255	3.272	1.334	17.89	18.32	18.10	24.70	23.90	24.29	20.89	170.0	-11.8	166.1	170.1	168.1	229.3	221.9	225.5	194.0
06-1	BASM	0.351	0.331	5.551	1.673	28.10	-1.87	3.287	3.285	0.015	19.15	19.08	19.11	26.55	25.21	25.86	22.15	21.0	-21.0	166.9	166.2	166.5	231.3	219.6	225.3	193.0
	MG-1	0.342	0.312	5.399	1.930	22.65	15.25	4.128	3.717	0.556	18.15	18.93	18.53	25.05	24.92	24.98	21.44	25.0	-28.6	159.3	166.1	162.7	219.8	218.7	219.2	188.1
	MG-2	0.386	0.349	5.471	1.561	29.40	11.35	6.038	5.249	1.043	18.36	18.77	18.56	26.05	22.65	24.23	21.11	21.0	-22.0	158.1	161.7	159.9	224.4	195.1	208.7	181.9
	MG-3	0.415	0.363	4.427	1.668	31.10	33.40	4.175	3.398	1.037	17.21	17.68	17.44	23.73	23.47	23.60	20.21	61.0	-29.8	156.3	160.6	158.4	215.5	213.2	214.3	183.6
	MG-4	0.366	0.322	4.709	1.383	40.05	15.60	5.631	4.783	1.179	17.93	18.08	18.00	25.14	21.73	23.31	20.39	140.5	-23.9	161.8	163.2	162.5	226.9	196.1	210.4	184.0
	MG-5	0.382	0.332	4.391	1.353	37.45	25.80	4.811	4.090	1.013	17.51	17.33	17.42	24.24	21.21	22.63	19.76	135.0	-9.9	162.6	160.9	161.7	225.1	197.0	210.1	183.5
04-3	BASM	0.177	0.166	3.315	0.840	15.83	1.20	3.457	3.403	0.072	18.26	18.17	18.21	25.85	25.59	25.72	21.59	39.5	-3.8	159.1	158.3	158.7	225.2	223.0	224.1	188.1
	MG-1	0.143	0.130	1.529	1.006	12.95	4.05	5.793	5.163	0.865	18.48	18.58	18.53	25.40	26.19	25.79	21.80	68.0	2.5	162.2	163.0	162.6	222.9	229.8	226.3	191.3
	MG-2	0.196	0.182	2.674	0.839	15.70	3.40	4.070	3.543	0.706	18.05	18.64	18.34	26.23	26.76	26.49	22.01	94.5	6.8	155.5	160.4	158.0	226.0	230.5	228.2	189.6
	MG-3	0.157	0.147	1.644	1.263	12.05	2.30	5.827	5.188	0.883	17.95	18.24	18.09	25.44	25.71	25.57	21.46	92.5	-3.8	163.0	165.6	164.3	231.0	233.5	232.2	194.9
	MG-4	0.276	0.256	1.948	1.040	3.70	19.40	8.566	7.268	1.782	18.32	18.47	18.39	25.23	26.49	25.84	21.75	103.0	-3.8	165.3	166.7	166.0	227.7	239.1	233.3	196.3
	MG-5	0.263	0.235	1.843	1.560	19.10	16.35	6.880	5.759	1.532	18.44	18.21	18.32	25.63	25.86	25.75	21.66	104.5	5.7	171.2	169.1	170.1	238.0	240.1	239.0	201.1
04-4	BASM	0.217	0.212	2.036	1.427	7.75	-1.45	3.506	3.505	0.007	18.73	19.85	19.27	26.75	27.22	26.98	22.74	51.5	4.0	163.1	172.9	167.9	233.1	237.1	235.1	198.1
	MG-1	0.148	0.129	0.945	1.527	24.55	1.25	4.017	3.409	0.804	18.84	19.29	19.06	26.48	26.99	26.74	22.52	127.5	4.2	165.3	169.3	167.3	232.4	236.9	234.6	197.6
	MG-2	0.163	0.142	1.480	1.952	22.40	5.20	4.178	4.009	0.224	18.71	19.78	19.23	27.12	26.92	27.02	22.74	75.5	4.0	161.2	170.4	165.7	233.6	231.9	232.8	195.9
	MG-3	0.133	0.118	0.504	1.475	16.75	4.05	4.632	4.023	0.838	18.64	19.05	18.84	25.76	26.27	26.11	22.11	193.5	14.6	169.3	173.0	171.1	235.7	238.6	237.1	200.8
	MG-4	0.235	0.221	0.928	1.877	17.20	2.05	4.248	3.986	0.365	18.05	18.63	18.74	26.13	26.57	26.35	22.16	154.0	9.0	170.1	168.2	169.1	235.8	239.8	237.8	200.0
	MG-5	0.129	0.117	0.511	1.880	14.10	1.85	7.556	6.568	1.358	18.46	19.03	18.74	26.07	25.96	26.01	22.01	87.0	14.1	171.4	176.7	174.0	242.0	241.0	241.5	204.4
C4-3	BASM	0.504	0.498	8.264	0.533	7.25	0.30	4.071	4.044	0.038	18.69	18.96	18.83	26.45	26.78	26.62	22.33	17.5	5.0	162.9	165.2	164.0	230.5	233.3	231.9	194.6
	MG-1	0.411	0.397	5.891	0.661	14.65	4.00	6.375	5.896	0.633	18.63	19.07	18.85	26.41	26.69	26.55	22.31	39.0	5.7	163.5	167.4	165.4	231.8	234.3	233.0	195.8
	MG-2	0.358	0.345	5.435	0.647	10.50	6.40	6.837	6.142	0.950	18.84	19.24	19.04	26.73	26.98	26.85	22.56	14.5	2.5	162.3	165.7	164.0	230.2	232.4	231.3	194.3
	MG-3	0.463	0.453	3.966	0.747	6.55	6.30	13.148	11.371	2.432	18.56	19.15	18.85	26.15	26.10	26.13	22.13	97.0	18.1	168.6	173.9	171.2	237.5	237.0	237.3	200.9
	MG-4	0.423	0.403	5.155	0.739	15.45	9.50	18.753	15.537	4.425	18.20	18.74	18.47	25.53	26.01	25.77	21.75	107.5	4.7	164.3	169.1	166.7	230.4	234.8	232.6	196.3
	MG-5	0.394	0.375	2.301	0.729	12.75	11.30	19.639	15.102	6.232	18.29	18.81	18.54	24.99	25.53	25.26	21.57	97.0	8.1	169.8	174.6	172.1	232.0	237.0	234.5	200.2
C4-4	BASM	0.367	0.350	2.906	0.700	18.95	3.65	3.785	3.765	0.022	18.31	18.77	18.54	25.90	25.87	25.89	21.84	45.5	10.1	159.5	163.6	161.5	225.7	225.4	225.5	190.3
	MG-1	0.291	0.269	2.082	0.819	19.75	8.85	4.813	4.397	0.573	18.19	18.61	18.39	25.46	25.84	25.65	21.66	92.0	2.4	159.6	163.3	161.4	223.5	226.7	225.1	190.1
	MG-2	0.307	0.296	2.359	0.876	14.20	1.20	4.831	4.330	0.696	18.16	18.66	18.41	25.79	26.08	25.94	21.80	87.5	-3.4	156.5	160.7	158.6	222.2	224.7	223.4	187.8
	MG-3	0.290	0.264	1.874	0.715	12.40	19.25	5.244	4.464	1.069	17.86	18.12	17.99	24.87	25.19	25.03	21.16	94.5	-1.4	162.2	164.6	163.4	225.9	228.8	227.3	192.2
	MG-4	0.234	0.202	1.762	0.786	13.45	24.85	6.617	5.675	1.293	17.84	18.21	18.02	24.94	25.36	25.15	21.23	145.5	13.0	161.0	164.4	162.7	225.1	228.9	227.0	191.6
	MG-5	0.207	0.186	1.501	1.039	8.75	17.50	5.619	4.726	1.225	17.82	18.03	17.93	24.97	24.83	24.90	21.06	76.5	11.2	165.4	167.4	166.4	231.8	230.5	231.2	195.6
10 CARS	BASM	0.319	0.305	4.570	0.999	18.86	0.75	2.909	2.869	0.055	20.05	20.16	20.11	28.03	28.07	28.05	23.69	50.5	-3.6	174.7	175.7	175.2	244.2	244.6	244.4	206.4
	MG-1	0.255	0.233	3.196	1.139	18.57	8.38	4.260	3.846	0.530	19.78	20.09	19.94	27.61	28.11	27.86	23.51	83.3	-2.6	173.6	176.3	175.0	242.3	246.7	244.4	206.3
	MG-2	0.286	0.269	3.806	1.103	15.65	5.95	4.548	3.996	0.755	19.83	20.02	19.92	27.81	27.72	27.77	23.47	77.8	-3.2	170.8	172.4	171.6	239.6	238.8	239.2	202.2
	MG-3	0.281	0.260	2.562	1.269	16.29	10.59	5.674	4.842	1.141	19.46	19.71	19.59	27.31	27.56	27.43	23.13	123.2	-3.1	176.7	179.0	177.9	248.0	250.3	249.1	210.0
	MG-4	0.313	0.287	3.323	1.236	19.48	14.10	6.927	5.827	1.513	19.57	19.72	19.64	27.34	27.14	27.24	23.08	120.3	-1.4	176.6	178.0	177.3	246.8	245.0	245.9	208.3
	MG-5	0.287	0.256	2.581	1.377	17.98	13.50	7.162	5.855	1.791	19.33	19.51	19.42	27.16	26.91	27.03	22.86	123.0	1.4	179.5	181.2	180.3	252.2	249.8	251.0	212.3

TABLE B-4. CAR/FUEL AVERAGE DATA (CONTINUED)

	BASM	0.240	0.229	3.268	1.358	14.99	-0.21	2.682	2.634	0.068	20.41	20.39	20.40	28.27	28.09	28.18	23.90	47.2	-5.4	177.8	177.6	177.7	246.3	244.7	245.5	208.3
	MG-1	0.193	0.175	2.393	1.533	18.70	5.89	3.530	3.119	0.552	20.15	20.32	20.23	27.89	28.25	28.07	23.76	83.2	-4.6	176.8	178.4	177.6	244.7	247.9	246.3	208.5
5 OPEN	MG-2	0.235	0.215	2.840	1.439	19.37	5.36	3.817	3.412	0.548	20.12	20.45	20.28	28.38	27.70	28.04	21.78	77.1	-3.3	173.3	176.2	174.7	244.5	238.7	241.6	204.9
	MG-3	0.236	0.212	2.055	1.498	18.98	10.57	3.987	3.434	0.754	19.74	19.89	19.81	27.45	27.53	27.49	23.27	128.1	-4.2	179.3	180.6	179.9	249.3	250.0	249.7	211.3
	MG-4	0.269	0.246	2.491	1.657	19.57	10.19	4.669	4.062	0.836	19.99	19.89	19.94	27.61	27.15	27.38	23.29	133.6	-5.5	180.4	179.6	180.0	249.2	245.0	247.1	210.3
	MG-5	0.242	0.217	2.221	1.775	20.79	10.77	4.882	4.130	1.020	19.65	19.71	19.68	27.33	26.67	26.99	22.98	115.8	0.8	182.4	183.0	182.7	253.7	247.6	250.6	213.3
	BASM	0.398	0.380	5.873	0.640	22.73	1.71	3.136	3.104	0.042	19.71	19.94	19.83	27.78	28.05	27.92	23.40	53.8	-1.8	171.7	173.8	172.7	242.1	244.4	243.2	204.6
5 CLOSED	MG-1	0.316	0.292	3.999	0.744	18.45	10.88	4.990	4.573	0.508	19.44	19.86	19.65	27.33	27.97	27.65	23.26	83.5	-0.6	170.6	174.3	172.4	239.8	245.5	242.6	204.1
	MG-2	0.337	0.322	4.771	0.768	11.94	6.54	5.280	4.580	0.961	19.55	19.60	19.57	27.26	27.74	27.50	23.16	78.6	-3.0	168.4	168.9	168.6	234.8	238.9	236.9	199.5
	MG-3	0.327	0.307	3.069	0.840	13.59	10.60	7.361	4.248	1.527	19.19	19.53	19.36	27.17	27.59	27.38	22.98	118.3	-2.0	174.3	177.4	175.8	246.7	250.6	248.6	208.7
	MG-4	0.358	0.327	4.156	0.815	19.40	18.01	9.184	7.592	2.190	19.16	19.55	19.35	27.08	27.13	27.11	22.86	107.1	2.8	173.0	176.5	174.7	244.4	244.9	244.7	206.4
	MG-5	0.321	0.296	2.942	0.879	15.18	14.39	9.442	7.571	2.542	19.03	19.32	19.17	27.00	27.15	27.07	22.75	130.3	1.9	176.7	179.4	178.0	250.7	252.0	251.4	211.2

NUMBER OF OBSERVATIONS

TABLE B-5. CAR/FUEL OBSERV.

CAR CODE	FUEL	FTP						SHED			FTP			HFET			MEAN	DRIVE-	VAPOR	FTP			HFET			MEAN
		ORG	HC	CO	NOX-C	ALD	ME-OH	ORG	HC	ME-OH	MPGC	MPGV	MPGA	MPGC	MPGV	MPGA	MPGA	ABILITY	LOCK	MPDC	MPDV	MPDA	MPDC	MPDV	MPDA	MPDA
04-1	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
04-2	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C4-1	BASH	4	4	4	3	4	4	2	2	2	4	4	4	4	4	4	4	2	2	4	4	4	4	4	4	4
	MG-1	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C4-2	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C6-1	BASH	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
06-1	BASH	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
04-3	BASH	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
04-4	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C4-3	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C4-4	BASH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	MG-5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10 CARS	BASH	25	25	25	24	25	24	22	22	22	25	25	25	25	25	25	25	20	20	25	25	25	25	25	25	25
	MG-1	21	21	21	21	21	21	21	21	20	21	21	21	21	21	21	21	20	20	21	21	21	21	21	21	21
	MG-2	21	21	21	21	21	20	20	20	20	21	21	21	21	21	21	21	20	20	21	21	21	21	21	21	21
	MG-3	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	20	20	21	21	21	21	21	21	21
	MG-4	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	MG-5	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

TABLE B-5. <u>CAR/FUEL OBSERVATIONS</u> (Continued)

5 OPEN	BASN	12	12	12	12	12	11	12	12	12	12	12	12	12	12	12	12	10	10	12	12	12	12	12	12	12
	MG-1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	MG-2	11	11	11	11	11	10	10	10	10	11	11	11	11	11	11	11	10	10	11	11	11	11	11	11	11
	MG-3	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	MG-4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	MG-5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5 CLOSED	BASN	13	13	13	12	13	13	10	10	10	13	13	13	13	13	13	13	10	10	13	13	13	13	13	13	13
	MG-1	11	11	11	11	11	11	11	11	10	11	11	11	11	11	11	11	10	10	11	11	11	11	11	11	11
	MG-2	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	MG-3	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10	11	11	11	11	11	11	11
	MG-4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	MG-5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

TABLE B-6. ABSOLUTE INCREASE BY CAR/FUEL RELATIVE TO BASE FUEL

INCREASE IN MEANS

CAR CODE	FUEL	FTP ORG	FTP HC	FTP CO	FTP NOX-C	FTP ALD	FTP ME-OH	SHED ORG	SHED HC	SHED ME-OH	FTP MPGC	FTP MPGV	FTP MPGA	HFET MPGC	HFET MPGV	HFET MPGA	MEAN MPGA	DRIVE-ABILITY	VAPOR LOCK	FTP MPGC	FTP MPGV	FTP MPGA	HFET MPGC	HFET MPGV	HFET MPGA	MEAN MPGA
04-1	MG-1	-0.033	-0.031	-0.401	0.206	-3.00	-0.15	0.367	0.278	0.091	-0.77	0.33	-0.21	0.32	0.28	0.30	0.02	37.0	2.9	-5.4	4.3	-0.3	4.9	4.5	4.7	1.9
	MG-2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	MG-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	127.0	[illegible]	[illegible]	12.4	[illegible]	11.3	13.2	12.3	10.3
	MG-4	-0.007	-0.011	-0.166	0.437	-2.10	5.30	1.286	1.030	0.346	-1.21	0.03	-0.56	-0.63	-0.22	-0.43	-0.50	95.5	0.0	-3.2	7.5	2.4	4.6	0.3	6.4	4.2
	MG-5	-0.001	-0.008	-0.232	0.339	4.15	4.45	1.333	1.042	0.438	-1.31	-0.06	-0.44	-0.52	-0.39	-0.45	-0.57	93.0	0.4	1.0	12.7	7.5	14.0	15.2	14.6	10.7
04-2	MG-1	-0.080	-0.105	-0.747	0.140	13.10	0.00	0.100	0.032	0.200	0.02	-0.36	-0.17	0.56	0.41	0.50	0.17	34.5	4.5	1.6	-1.7	-0.1	6.8	7.3	7.0	3.1
	MG-2	-0.035	-0.045	-0.420	-0.130	7.55	4.95	0.521	0.311	0.310	0.02	-0.13	-0.06	0.57	0.70	0.47	0.27	30.5	1.0	-2.1	-1.4	-2.7	1.9	3.6	2.7	-0.3
	MG-3	0.045	0.027	-0.719	0.605	13.15	9.50	0.426	0.175	0.355	-0.20	-0.14	-0.36	1.01	0.37	0.69	0.11	40.5	-0.9	5.0	4.3	5.1	20.4	14.0	17.7	10.7
	MG-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	MG-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35.5	[illegible]	3.5	[illegible]	[illegible]	[illegible]	15.3	[illegible]	9.3
C4-1	MG-1	-0.095	-0.087	-3.070	0.097	-10.25	2.05	3.656	3.223	0.321	0.31	-0.37	-0.04	0.79	-0.17	0.33	0.11	31.0	3.4	4.0	-2.1	1.0	9.0	0.7	5.0	2.7
	MG-2	-0.070	-0.061	-2.701	0.018	-15.15	3.65	3.200	2.095	1.510	-0.37	-1.75	-1.10	-1.36	-1.44	-1.40	-1.27	30.5	-1.1	-5.5	-10.2	-12.3	-14.7	-15.0	-15.3	-13.0
	MG-3	-0.114	-0.104	-4.092	0.420	-10.65	-1.90	4.310	1.998	1.642	-0.20	-0.14	-0.55	-0.84	-1.00	-0.51	-0.56	[illegible]	-1.1	[illegible]	[illegible]	[illegible]	11.7	2.9	7.5	[illegible]
	MG-4	-0.041	-0.043	-3.303	0.257	0.70	1.50	0.620	6.401	2.704	-0.27	-0.14	-0.41	0.20	-0.00	-0.32	-0.19	36.0	5.1	4.2	-1.6	1.3	12.0	2.0	7.6	4.0
	MG-5	0.002	0.001	-3.606	0.143	-15.25	14.50	6.386	4.902	2.025	-0.52	-0.10	-0.70	0.01	-1.34	-0.64	-0.69	117.0	4.0	7.5	4.3	5.9	10.7	7.3	13.2	9.1
C4-2	MG-1	-0.090	-0.094	0.124	0.008	-1.65	4.15	1.717	1.517	0.532	-0.28	0.45	0.07	-1.47	-0.45	-0.97	-0.40	5.5	0.1	-1.0	5.3	2.1	-11.1	-2.0	-6.7	-1.7
	MG-2	-0.002	-0.070	-0.400	0.100	-16.50	9.75	2.426	1.736	0.937	-0.11	-0.27	-0.17	-1.55	-0.07	-0.87	-0.49	14.5	0.5	-3.0	-4.4	-3.7	-16.2	-3.5	-10.4	-6.7
	MG-3	-0.090	-0.097	-1.631	0.036	-6.65	6.35	2.075	1.000	1.292	-0.10	0.19	0	0.77	0.07	0.17	0.09	33.0	-1.9	6.2	9.5	7.8	13.3	11.0	12.4	10.0
	MG-4	0.042	0.035	-0.722	0.061	-17.90	21.15	2.227	1.310	1.270	-0.21	-0.11	-0.05	-0.16	0.07	-0.05	-0.05	16.0	5.5	4.0	7.4	6.2	7.6	10.1	0.0	7.4
	MG-5	-0.073	-0.073	-1.205	0.231	-17.45	14.10	5.804	4.410	1.096	-0.40	-0.47	-0.48	0.45	0.30	0.40	-0.04	27.5	2.4	7.4	7.8	7.7	22.5	20.1	21.4	13.0
C6-1	MG-1	-0.059	-0.071	-2.427	0.218	-17.70	28.73	0.340	0.121	0.332	-1.00	-0.30	-0.73	-0.76	0.19	-0.27	-0.53	41.0	9.2	-0.3	-2.1	-5.2	-5.0	3.2	-0.8	-3.2
	MG-2	0.053	0.060	1.259	0.203	-20.00	7.00	1.271	0.005	0.526	-0.36	-0.00	-0.14	-0.24	-0.77	-0.52	-0.31	40.0	10.7	-5.0	-1.2	-3.1	-4.7	7.1	7.0	-4.0
	MG-3	-0.025	-0.032	-2.765	0.314	-13.13	10.40	1.414	0.000	0.031	-1.46	-0.03	-1.15	-1.53	-0.07	-0.70	-0.90	47.0	0.4	-4.1	-0.5	-3.3	-4.2	0.5	2.3	-0.0
	MG-4	0.012	-0.011	-0.226	0.262	-2.15	26.43	1.017	1.007	1.020	-1.15	-0.36	-0.76	-1.17	-1.97	-1.61	-1.14	24.5	7.7	-4.3	2.0	-0.0	-2.4	-10.1	-6.5	-3.4
	MG-5	-0.042	-0.060	-2.401	0.283	-0.35	19.73	1.930	1.000	1.203	-1.42	-0.00	-1.15	-1.50	-0.90	-1.23	-1.17	125.5	0.0	-2.1	2.0	0.3	1.1	5.1	3.2	1.4
06-1	MG-1	-0.000	-0.019	-0.152	0.257	-5.45	17.12	0.841	0.432	0.542	-1.00	-0.15	-0.50	-1.50	-0.27	-0.00	-0.72	4.0	-7.6	-7.5	-0.1	-3.9	-11.5	-1.0	-6.1	-4.9
	MG-2	0.035	0.010	-0.000	-0.112	1.30	13.22	2.751	1.965	1.020	-0.79	-0.31	-0.55	-0.50	-2.56	-1.63	-1.04	0	-0.9	-0.7	-4.5	-6.6	-6.9	-24.5	-16.6	-11.1
	MG-3	0.065	0.032	-1.124	-0.005	3.00	35.27	0.000	0.114	1.023	-1.74	-1.39	-1.67	-2.02	-1.73	-2.26	-1.94	40.0	-0.0	-10.6	-5.6	-0.1	-15.0	-6.4	-11.0	-9.4
	MG-4	0.015	-0.007	-1.012	-0.270	11.75	17.47	2.391	1.390	1.169	-1.21	-1.00	-1.11	-1.91	-3.40	-2.55	-1.76	119.5	-7.0	-5.1	-3.0	-4.1	-4.4	-23.5	-14.9	-9.0
	MG-5	0.032	0	-1.160	-0.370	9.35	27.67	1.524	0.805	0.999	-1.84	-1.75	-1.70	-2.31	-3.97	-3.23	-2.39	114.0	11.1	-4.3	-5.3	-4.0	-6.3	-22.7	-15.2	-9.5
04-3	MG-1	-0.034	-0.036	-1.705	0.166	-2.00	2.05	2.336	1.760	0.793	0.22	0.41	0.32	-0.45	0.60	0.07	0.21	20.5	6.3	3.1	4.7	3.9	-2.3	6.9	2.2	3.2
	MG-2	0.019	0.016	-0.641	-0.001	-0.13	7.29	0.613	0.140	0.634	-0.21	0.47	-0.13	-0.30	1.17	-0.77	-0.42	55.0	10.7	-3.6	2.3	-0.7	0.7	7.6	4.1	1.5
	MG-3	-0.019	-0.019	-1.670	0.423	3.70	1.10	2.370	1.705	0.011	-0.30	0.07	-0.12	-0.42	0.12	-0.15	-0.13	53.0	7.6	4.0	7.3	5.6	5.0	10.5	0.1	4.0
	MG-4	0.079	0.071	-1.366	0.200	-12.13	10.20	5.109	3.064	1.711	0.06	0.30	0.10	-0.63	0.90	0.12	0.16	63.5	0	6.3	0.4	7.3	2.4	16.2	9.2	0.2
	MG-5	0.007	0.069	-1.471	0.720	3.27	15.15	3.423	2.356	1.460	0.10	0.04	0.11	-0.22	0.27	0.03	0.07	45.0	9.5	12.1	10.0	11.4	12.7	17.2	14.9	13.0
04-4	MG-1	-0.069	-0.083	-1.091	0.109	16.80	2.70	0.511	-0.096	0.798	0.11	-0.55	-0.21	-0.27	-0.22	-0.25	-0.22	76.0	-1.0	2.2	-3.6	-0.6	-0.7	-0.2	-0.5	-0.3
	MG-2	-0.054	-0.070	-0.556	0.524	14.65	6.65	0.672	0.504	0.217	-0.01	-0.06	-0.04	0.37	-0.29	0.04	0	24.0	-2.0	-2.0	-2.5	-2.2	0.6	-5.2	-2.3	-2.3
	MG-3	-0.003	-0.095	-1.532	0.047	9.00	5.50	1.126	0.520	0.031	-0.07	-0.00	-0.43	-0.00	-0.75	-0.07	-0.63	142.0	0.6	1.1	-1.1	3.2	2.6	1.4	2.1	2.7
	MG-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	102.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	MG-5	-0.088	-0.095	-1.525	0.453	4.35	3.30	4.650	3.003	1.350	-0.24	-0.02	-0.53	-0.09	-1.26	-0.97	-0.73	35.5	0.1	6.3	3.0	4.1	0.9	3.9	2.4	4.3
C4-3	MG-1	-0.092	-0.101	-2.372	0.120	7.40	3.70	2.304	1.052	0.595	-0.06	0.11	0.02	-0.04	-0.07	-0.04	-0.02	21.5	0.7	0.6	2.2	1.4	1.3	0.9	1.1	1.3
	MG-2	-0.146	-0.154	-2.829	0.134	3.25	6.10	2.766	2.097	0.913	0.15	0.27	0.21	0.27	0.20	0.24	0.22	-3.0	-2.5	-0.6	0.5	0	-0.2	-0.9	-0.6	-0.3
	MG-3	-0.040	-0.045	-4.298	0.214	-0.70	6.00	9.077	7.327	2.394	-0.13	0.19	0.03	-0.30	-0.68	-0.49	-0.21	79.5	13.1	5.7	0.7	7.2	7.0	3.7	5.4	6.4
	MG-4	-0.081	-0.095	-3.109	0.706	0.20	9.20	14.602	11.493	4.307	-0.49	-0.22	-0.36	-0.92	-0.77	-0.85	-0.50	90.0	-0.3	1.4	3.9	2.6	0	1.4	0.7	1.0
	MG-5	-0.110	-0.124	-5.963	0.196	5.50	11.00	15.568	11.050	6.195	-0.41	-0.16	-0.28	-1.47	-1.25	-1.36	-0.77	79.5	3.1	4.9	9.4	0.1	1.5	3.7	2.6	5.7
C4-4	MG-1	-0.076	-0.082	-0.824	0.119	0.00	5.20	1.028	0.631	0.551	-0.12	-0.17	-0.14	-0.44	-0.03	-0.24	-0.19	46.5	-7.7	0.1	-0.3	-0.1	-2.2	1.3	-0.5	-0.3
	MG-2	-0.060	-0.055	-0.547	0.176	-4.75	-2.45	1.046	0.565	0.674	-0.14	-0.12	-0.13	-0.11	0.21	0.05	-0.05	42.0	-13.6	-3.0	-2.9	-2.9	-3.5	-0.7	-2.1	-2.6
	MG-3	-0.077	-0.086	-1.732	0.015	-6.55	15.60	1.459	0.619	1.047	-0.45	-0.65	-0.55	-1.03	-0.60	-0.86	-0.67	49.0	-11.5	2.7	1.0	1.9	0.2	3.4	1.0	1.0
	MG-4	-0.133	-0.140	-1.144	0.006	-5.50	21.20	2.032	1.719	1.271	-0.47	-0.56	-0.52	-0.97	-0.51	-0.74	-0.61	100.0	2.0	1.5	0.0	1.2	-0.6	3.5	1.9	1.3
	MG-5	-0.160	-0.165	-1.405	0.339	-10.20	13.05	1.034	0.961	1.203	-0.49	-0.74	-0.61	-0.93	-1.04	-0.99	-0.70	31.0	1.0	6.0	3.9	4.9	6.2	5.1	5.6	5.3
10 CARS	MG-1	-0.064	-0.071	-1.375	0.140	-0.20	7.43	1.350	0.977	0.475	-0.27	-0.07	-0.17	-0.42	0.04	-0.19	-0.10	32.0	1.0	-1.1	0.6	-0.2	-1.9	2.1	0.1	-0.1
	MG-2	-0.033	-0.036	-0.765	0.104	-3.20	5.20	1.639	1.127	0.700	-0.22	-0.15	-0.10	-0.21	-0.35	-0.20	-0.22	27.3	0.4	-3.9	-3.2	-3.6	-4.6	-5.0	-5.2	-4.3
	MG-3	-0.030	-0.045	-2.009	0.270	-2.57	9.04	2.765	1.973	1.006	-0.59	-0.45	-0.52	-0.72	-0.51	-0.61	-0.57	72.7	0.5	2.0	3.3	2.7	3.0	5.7	4.0	3.6
	MG-4	-0.006	-0.010	-1.247	0.237	0.63	13.35	4.017	2.950	1.450	-0.49	-0.44	-0.46	-0.60	-0.93	-0.01	-0.61	69.0	2.3	1.9	2.3	2.1	2.6	0.4	1.5	1.9
	MG-5	-0.037	-0.040	-1.989	0.320	-0.07	12.03	4.253	2.986	1.736	-0.72	-0.65	-0.60	-0.86	-1.16	-1.01	-0.83	72.5	5.0	4.0	5.5	5.2	0.0	5.2	6.6	5.0
5 OPEN	MG-1	-0.046	-0.055	-0.075	0.173	3.71	6.10	0.047	0.403	0.404	-0.26	-0.06	-0.16	-0.39	0.16	-0.11	-0.14	36.0	0.9	-1.0	0.7	-0.2	-1.6	3.2	0.0	0.3
	MG-2	-0.005	-0.014	-0.420	0.001	4.30	5.57	1.134	0.779	0.400	-0.29	0.06	-0.11	0.11	-0.39	-0.14	-0.12	29.9	2.1	-4.5	-1.5	-3.0	-1.0	-6.1	-4.0	-3.4
	MG-3	-0.004	-0.017	-1.213	0.340	3.99	10.70	1.304	0.802	0.606	-0.67	-0.50	-0.50	-0.02	-0.56	-0.69	-0.63	80.9	1.3	1.4	3.0	2.2	3.0	5.3	4.1	3.1
	MG-4	0.029	0.016	-0.777	0.299	4.50	10.40	1.906	1.420	0.760	-0.42	-0.49	-0.46	-0.67	-0.94	-0.00	-0.61	[illegible]	-0.1	2.6	1.9	2.3	2.9	0.3	1.6	2.9
	MG-5	0.002	-0.012	-1.047	0.417	5.80	10.98	2.199	1.504	0.952	-0.76	-0.67	-0.72	-0.95	-1.42	-1.19	-0.93	[illegible]	6.2	4.6	5.4	5.0	7.4	2.9	5.1	5.1
5 CLOSED	MG-1	-0.082	-0.087	-1.074	0.104	-4.20	9.17	1.053	1.469	0.446	-0.27	-0.08	-0.18	-0.45	-0.00	-0.27	-0.22	29.7	1.2	-1.1	0.5	-0.3	-2.2	1.1	-0.6	-0.5
	MG-2	-0.061	-0.058	-1.101	0.120	-10.77	4.83	2.144	1.476	0.917	-0.16	-0.34	-0.25	-0.52	-0.32	-0.42	-0.32	21.0	-1.2	-3.3	-1.7	-4.1	-7.2	-5.5	-6.4	-5.1
	MG-3	-0.071	-0.073	-2.804	0.200	-9.14	8.07	4.225	3.144	1.405	-0.52	-0.41	-0.46	-0.62	-0.46	-0.54	-0.50	64.5	-0.2	2.6	3.6	3.1	4.6	6.1	5.4	4.1
	MG-4	-0.040	-0.052	-1.717	0.175	-3.33	16.30	6.040	4.400	2.148	-0.55	-0.39	-0.47	-0.70	-0.92	-0.81	-0.67	53.3	4.6	1.2	2.7	2.0	2.4	0.5	1.4	1.0
	MG-5	-0.077	-0.084	-2.931	0.239	-7.55	14.60	6.306	4.447	2.520	-0.60	-0.63	-0.65	-0.70	-0.91	-0.81	-0.74	76.5	3.7	5.0	5.6	5.3	0.6	7.6	0.1	6.6

TABLE B-7. PERCENT INCREASE BY CAR/FUEL RELATIVE TO BASE FUEL

PERCENT INCREASE IN MEANS

CAR CODE	FUEL	FTP ORG	FTP HC	FTP CO	FTP NOX-C	FTP ALD	FTP HC-OH	SHED ORG	SHED HC	SHED HC-OI
04-1	MG-1	-10.1	-10.0	-29.6	12.6	-21.1	-27.3	25.1	22.7	45.5
	MG-2	5.9	6.5	-21.0	8.1	-10.2	154.5	78.0	74.0	100.0
	MG-3	-15.9	-17.7	-50.2	33.5	-9.9	463.6	116.6	107.9	205.3
	MG-4	-4.1	-6.1	-0.2	26.7	-14.0	763.6	87.7	70.4	102.5
	MG-5	-0.0	-4.9	-11.4	20.7	29.2	809.1	92.3	79.3	218.3
04-2	MG-1	-32.5	-39.7	-21.9	12.3	144.0	1600.0	10.6	1.9	442.3
	MG-2	-13.1	-17.2	-12.4	-11.5	83.4	990.0	30.7	10.7	702.9
	MG-3	16.0	20.4	-21.1	56.6	145.3	1900.0	25.2	10.3	785.6
	MG-4	7.4	0.7	-11.9	57.9	174.0	1510.0	26.6	16.0	532.2
	MG-5	-6.5	-9.5	-24.9	73.0	65.2	870.0	38.0	15.3	1136.0
C4-1	MG-1	-25.6	-25.5	-55.6	6.2	-43.5	43.2	115.4	103.6	906.0
	MG-2	-10.0	-17.6	-40.0	2.3	-64.3	76.0	101.3	67.3	1961.5
	MG-3	-31.4	-28.0	-58.0	55.4	-79.2	-40.0	200.4	140.6	2340.0
	MG-4	-11.1	-12.2	-40.6	34.2	3.0	31.6	272.4	212.2	3527.0
	MG-5	0.5	0.2	-51.0	10.9	-64.0	305.3	201.6	157.5	2544.3
C4-2	MG-1	-22.6	-25.0	2.9	1.4	-5.0	304.4	81.9	65.3	2060.2
	MG-2	-20.6	-20.0	-14.2	19.0	-57.7	609.4	103.6	74.6	5050.9
	MG-3	-24.7	-26.3	-30.1	6.4	-23.3	376.9	120.7	81.1	6963.1
	MG-4	10.7	9.3	-16.9	10.0	-62.6	1446.9	97.3	57.9	6040.0
	MG-5	-10.4	-19.4	-20.2	40.7	-61.0	881.2	247.9	189.7	10221.0
C6-1	MG-1	-16.0	-22.0	-34.9	33.0	-50.1	-1457.7	15.5	5.3	610.4
	MG-2	15.1	10.4	10.1	31.5	-50.9	-400.7	34.9	30.9	1013.0
	MG-3	-7.1	-9.0	-39.8	40.6	-37.2	-1061.5	61.0	35.6	1602.0
	MG-4	3.5	-3.4	-3.3	40.5	-6.1	-1525.0	70.5	47.0	1901.6
	MG-5	-11.9	-10.4	-35.7	43.9	-1.0	-1150.0	83.7	44.0	2471.3
06-1	MG-1	-2.3	-5.7	-2.7	15.4	-19.4	-917.0	25.6	13.2	3605.4
	MG-2	10.0	5.4	-1.4	-6.7	4.6	-700.0	83.7	59.0	6975.2
	MG-3	10.5	9.4	-20.2	-0.3	10.7	-1089.3	27.0	3.5	6957.1
	MG-4	4.4	-2.7	-15.2	-17.3	42.5	-935.7	71.3	45.6	7919.0
	MG-5	4.1	6.1	-20.9	-16.1	33.3	-1482.1	40.1	31.5	6793.5
04-3	MG-1	-19.1	-21.5	-53.9	19.0	-10.2	237.5	47.6	51.7	1103.4
	MG-2	10.9	9.7	-19.3	-0.1	-0.0	103.3	17.7	4.1	902.0
	MG-3	-10.0	-11.4	-50.4	50.4	-23.9	91.7	40.5	52.1	1128.5
	MG-4	56.2	54.7	-41.2	23.0	-76.6	1516.7	147.0	113.6	2380.1
	MG-5	49.2	41.9	-44.4	85.7	20.6	1262.5	99.0	49.2	2031.4
04-4	MG-1	-31.0	-39.2	-53.6	7.0	216.0	-106.2	14.6	-2.7	10759.5
	MG-2	-24.9	-33.1	-27.3	36.7	109.0	-450.6	19.2	16.4	2933.7
	MG-3	-30.5	-40.6	-75.2	3.3	110.1	-377.3	32.1	14.0	11229.7
	MG-4	0.3	4.2	-51.5	31.5	121.1	-241.1	26.2	13.7	4034.6
	MG-5	-40.8	-45.0	-74.9	31.7	81.5	-227.1	115.5	87.1	10215.5
C4-3	MG-1	-18.4	-20.3	-20.7	24.6	102.1	1233.3	36.6	45.0	1583.4
	MG-2	-29.0	-30.0	-34.2	25.1	44.0	2033.3	67.9	51.9	2427.1
	MG-3	-0.0	-9.1	-52.0	40.2	-9.7	2000.0	223.0	101.2	6367.3
	MG-4	-16.1	-19.1	-37.6	30.7	113.1	3066.7	360.6	204.2	11040.6
	MG-5	-21.0	-24.0	-72.2	36.0	75.9	3664.7	302.4	273.4	16475.5
C4-4	MG-1	-20.0	-23.3	-20.4	17.1	4.2	142.5	27.2	16.0	2402.2
	MG-2	-16.5	-15.7	-10.0	25.1	-25.1	-67.1	27.6	15.0	3035.4
	MG-3	-21.0	-24.6	-42.4	2.2	-34.6	427.4	30.6	10.6	4714.6
	MG-4	-36.3	-43.1	-38.4	12.3	-29.0	500.0	71.0	50.2	5221.0
	MG-5	-43.5	-47.1	-46.3	40.5	-53.0	379.5	40.5	25.5	5416.9
10 CARS	MG-1	-20.2	-23.4	-30.1	10.0	-1.5	1010.0	84.4	30.1	845.9
	MG-2	-10.3	-11.9	-16.7	19.5	-17.0	693.3	56.3	37.3	1274.4
	MG-3	-11.9	-14.7	-43.9	27.0	-13.6	1311.6	75.0	60.0	1977.4
	MG-4	-1.7	-5.9	-27.3	23.7	3.3	1780.0	138.1	103.3	2655.4
	MG-5	-11.6	-15.0	-43.5	32.8	-4.6	1710.7	146.2	104.1	3142.2
5 OPEN	MG-1	-17.4	-23.9	-26.0	12.9	24.0	-2060.9	31.6	10.4	712.7
	MG-2	-2.0	-6.1	-13.1	6.0	29.2	-2612.5	42.3	29.6	706.1
	MG-3	-1.0	-7.4	-37.1	25.0	26.6	-5054.7	40.6	30.5	1009.0
	MG-4	17.1	2.1	-33.0	32.1	30.6	-4076.4	73.1	53.2	1122.6
	MG-5	1.0	-5.2	-37.0	30.7	38.7	-5140.4	82.0	57.1	1406.9
5 CLOSED	MG-1	-20.7	-23.0	-31.9	16.3	-10.0	535.0	59.1	47.3	1114.9
	MG-2	-15.3	-15.2	-10.0	20.0	-47.5	201.7	60.3	47.5	2197.9
	MG-3	-17.9	-19.1	-47.7	31.2	-40.2	510.9	134.7	101.3	3550.5
	MG-4	-10.1	-13.0	-29.2	27.3	-11.7	951.2	197.0	144.6	5135.7
	MG-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CAR CODE	FUEL	FTP MPGC	FTP MPGV	FTP MPGA	HFET MPGC	HFET MPGV	HFET MPGA	MEAN MPGA	DRIVE-ABILITY	VAPOR LOCK	FTP MPDC	FTP MPDV	FTP MPDA	HFET MPDC	HFET MPDV	HFET MPDA	MEAN MPDA
04-1	MG-1	-3.2	1.4	-0.9	1.0	0.9	0.9	0.1	49.3	-59.0	-2.5	[illegible]	-0.2	1.7	1.4	1.6	0.0
	MG-2	-1.4	1.5	0.1	-0.0	-0.3	-0.5	-0.3	53.3	-30.1	-2.5	[illegible]	-1.1	-1.9	-1.4	-1.7	1.4
	MG-3	-1.6	1.9	0.1	-0.3	0.4	0	0.1	172.0	4.1	2.5	6.2	0.4	0.0	1.6	0.3	0.3
	MG-4	0.9	0.1	-2.4	-1.9	-0.7	-1.3	-1.0	127.3	-16.5	-1.5	3.7	1.1	1.6	2.9	2.2	1.7
	MG-5	-5.3	-0.2	-2.0	-1.6	-1.2	-1.4	-2.0	124.0	-9.3	0.9	6.3	3.6	4.9	5.3	5.1	4.4
04-2	MG-1	0.1	-1.6	-0.0	1.0	1.9	1.9	0.6	70.4	-128.6	0.0	-0.9	-0.1	2.6	2.7	2.6	1.4
	MG-2	0.1	-0.6	-0.3	1.9	2.5	2.2	1.0	62.2	-28.6	-1.1	-1.7	-1.4	0.7	1.3	1.0	0.1
	MG-3	-1.2	-2.0	-1.6	3.2	1.2	2.2	0.4	82.7	25.7	2.9	2.2	2.4	7.7	5.5	6.6	0.7
	MG-4	-0.1	-1.9	-1.0	0.9	-0.1	0.4	-0.3	101.1	42.9	3.5	1.7	2.6	1.5	3.1	1.0	1.3
	MG-5	-4.5	-2.1	-3.3	-2.2	-0.0	-1.5	-2.4	73.4	-57.3	1.0	4.4	3.1	4.2	5.7	4.9	4.0
C4-1	MG-1	1.4	-1.0	-0.2	2.4	-0.5	1.0	0.4	39.5	-266.7	2.2	-1.1	0.5	3.2	0.2	1.7	1.1
	MG-2	-1.0	-0.0	-3.4	-4.2	-4.2	-4.2	-4.0	35.5	92.6	-2.9	-9.9	-6.5	-5.2	-5.3	5.3	5.0
	MG-3	-0.9	-4.1	-2.5	-0.1	-3.1	-1.6	-2.1	109.3	100.0	3.2	0	1.6	1.1	1.0	2.6	2.1
	MG-4	-1.3	-4.3	-2.0	0.6	-2.6	-0.9	-1.0	41.9	-377.0	2.2	-0.0	0.7	1.2	0.9	2.6	1.7
	MG-5	-2.4	-4.6	-3.2	0	-3.9	-1.9	-2.5	130.4	-300.0	4.0	2.2	3.1	6.6	2.4	4.5	3.9
C4-2	MG-1	-1.2	2.1	0.4	-5.1	-1.5	-3.4	-1.6	7.3	-3.3	-0.5	2.9	1.1	-1.4	-0.0	2.7	0.9
	MG-2	-0.5	-1.3	-0.9	-5.4	-0.2	-2.9	-2.6	19.2	-16.7	-1.6	-2.4	-2.0	-6.4	-1.3	1.0	-1.1
	MG-3	-0.9	0.9	0	1.0	0.2	0.6	0.3	43.7	63.3	3.3	5.2	4.7	5.3	4.5	4.9	4.6
	MG-4	-1.0	0.5	-0.2	-0.6	0.2	-0.2	-0.2	21.2	-103.3	2.6	4.1	3.4	3.0	3.0	3.4	3.4
	MG-5	-2.3	-2.2	-2.2	2.2	1.0	1.6	-0.2	36.4	-81.7	4.1	4.2	4.2	9.0	7.6	8.3	6.4
C6-1	MG-1	-5.6	-2.0	-3.0	-2.9	0.7	-1.1	-2.4	92.1	-46.6	-4.9	-1.3	-3.1	-2.2	1.5	-0.3	-1.7
	MG-2	-1.0	0.4	-0.7	-0.9	-3.1	-2.0	-1.4	89.9	-53.9	-3.0	-0.7	-1.0	-2.0	-4.2	-3.2	-2.3
	MG-3	-7.6	-4.1	-6.0	-5.0	-0.1	-3.1	-4.5	150.6	-3.3	-3.7	-0.3	-2.0	-1.0	3.9	1.0	-0.4
	MG-4	-5.9	-1.9	-3.9	-4.5	-0.0	-6.3	-5.2	55.1	-50.1	-2.6	1.7	-0.5	-1.0	-4.7	-2.9	-1.6
	MG-5	-7.3	-4.6	-6.0	-5.7	-4.0	-4.0	-5.4	202.0	-40.4	-1.3	1.7	0.2	0.5	2.3	1.4	0.0
06-1	MG-1	-5.2	-0.0	-3.0	-5.7	-1.6	-3.4	-3.2	19.0	36.1	-4.5	-0.1	-2.3	-3.0	-0.4	-2.7	-2.5
	MG-2	-4.1	-1.6	-2.9	-1.9	-10.2	-6.3	-4.7	0	9.5	-5.2	-2.7	-4.0	-3.0	-11.2	-7.4	-5.0
	MG-3	-10.1	-7.3	-0.7	-10.6	-0.9	-0.7	-0.0	190.5	41.0	-6.3	-3.4	-4.9	-6.0	-2.9	-4.9	-4.9
	MG-4	-6.4	-5.2	-5.0	-5.3	-13.0	-9.9	-0.0	567.0	23.5	-3.0	-1.0	-2.4	-1.9	-10.7	-6.4	-4.4
	MG-5	-0.0	-9.2	-5.0	-0.7	-15.0	-12.5	-10.0	542.9	-57.7	-2.8	-3.2	-2.9	-2.7	-18.3	-6.8	-4.8
04-3	MG-1	1.2	2.2	1.7	-1.7	2.3	0.3	1.0	72.2	-164.9	2.0	3.0	2.5	-1.0	3.1	1.0	1.7
	MG-2	-1.1	2.6	0.7	1.5	4.6	3.0	1.7	139.2	-277.9	-2.3	1.1	-0.4	0.3	3.4	1.0	0.9
	MG-3	-1.7	0.6	-0.6	-1.6	0.5	-0.6	-0.6	134.2	-190.7	2.5	4.6	3.6	2.6	4.7	3.6	3.6
	MG-4	0.3	1.7	1.0	-2.4	3.5	0.5	0.7	160.0	-1.3	3.9	3.3	4.4	1.1	7.2	4.1	4.3
	MG-5	1.0	0.2	0.6	-0.9	1.1	0.1	0.3	144.6	-240.1	7.4	6.0	7.2	5.7	7.7	6.7	6.9
04-4	MG-1	0.6	-2.0	-1.1	-1.0	-0.0	-0.9	-1.0	107.6	-29.0	1.3	-2.1	-0.4	-0.3	-0.1	-0.2	-0.3
	MG-2	-0.1	-0.3	-0.2	1.4	-1.1	0.1	0	46.6	-33.1	-1.2	-1.4	-1.3	0.2	-2.2	-1.0	-1.1
	MG-3	-0.3	-0.0	-2.2	-3.0	-3.5	-3.2	-3.0	275.7	142.1	3.0	0	1.9	1.1	0.6	0.9	1.4
	MG-4	0.6	-6.1	-3.0	-2.1	-2.1	-2.1	-3.5	177.0	40.0	4.1	-2.0	0.2	1.2	1.1	1.2	1.1
	MG-5	-1.4	-4.1	-2.7	-2.8	-4.6	-3.1	-3.2	60.9	133.9	5.1	3.2	3.7	3.0	1.6	2.7	3.2
C4-3	MG-1	-0.3	0.4	0.1	-0.2	-0.3	-0.2	-0.1	122.9	15.0	0.1	1.3	0.0	0.6	0.4	0.5	0.6
	MG-2	0.0	1.4	1.1	1.0	0.0	0.9	1.0	-17.1	-50.0	-0.3	0.3	0	-0.1	-0.4	-0.2	-0.1
	MG-3	-0.7	1.0	0.1	-1.1	-2.5	-1.0	-0.9	454.3	262.0	3.5	5.3	4.4	3.0	1.6	2.3	3.3
	MG-4	-2.6	-1.2	-1.9	-3.5	-2.9	-3.2	-2.6	514.3	-6.0	0.9	2.4	1.6	0	0.6	0.3	0.9
	MG-5	-2.2	-0.0	-1.5	-5.5	-4.7	-5.1	-3.4	454.3	63.0	4.2	5.7	5.0	0.7	1.6	1.1	2.9
C4-4	MG-1	-0.6	-0.9	-0.8	-1.7	-0.1	-0.9	-0.8	102.2	-75.9	0.1	-0.2	-0.1	-1.0	0.6	-0.2	-0.1
	MG-2	-0.0	-0.6	-0.7	-0.4	0.0	0.2	-0.2	72.3	-134.0	-1.9	-1.7	-1.0	-1.6	-0.3	-0.9	-1.3
	MG-3	-2.4	-3.5	-2.9	-4.0	-2.6	-3.3	-3.1	107.7	-113.0	1.7	0.6	1.2	0.1	1.5	0.0	1.0
	MG-4	-2.4	-3.0	-2.0	-3.2	-2.0	-2.9	-2.0	212.0	20.1	0.9	0.5	0.7	-0.3	1.6	0.6	0.7
	MG-5	-2.7	-3.9	-3.3	-3.6	-4.0	-3.6	-3.6	60.1	10.3	3.7	2.4	3.1	2.7	2.3	2.5	2.6
10 CARS	MG-1	-1.3	-0.4	-0.9	-1.5	0.1	-0.7	-0.8	65.0	-20.6	-0.6	0.4	-0.1	-0.8	0.9	0	-0.1
	MG-2	-1.1	-0.7	-0.9	-0.8	-1.2	-1.0	-0.9	54.2	-12.3	-2.2	-1.0	-2.0	-1.9	-2.4	-2.1	-2.1
	MG-3	-2.9	-2.2	-2.6	-2.6	-1.0	-2.2	-2.4	144.0	-11.6	1.2	1.9	1.5	1.6	2.3	2.0	1.7
	MG-4	-2.9	-2.2	-2.3	-2.4	-3.3	-2.9	-2.6	138.3	-62.2	1.1	1.3	1.2	1.1	0.2	0.6	0.9
	MG-5	-3.6	-3.2	-3.4	-3.1	-4.1	-3.6	-3.5	143.7	-137.0	2.7	3.1	2.9	3.3	2.1	2.7	2.0
5 OPEN	MG-1	-1.3	-0.3	-0.8	-1.4	0.6	-0.4	-0.6	74.3	-16.0	-0.6	0.4	-0.1	-0.7	1.3	0.3	0.1
	MG-2	-1.4	0.3	-0.6	0.4	-1.4	-0.5	-0.5	63.3	-39.0	-2.5	-0.0	-1.7	-0.7	-2.5	-1.6	-1.6
	MG-3	-3.3	-2.4	-2.9	-2.9	-2.0	-2.4	-2.6	171.4	-23.3	0.0	1.7	1.3	1.2	2.2	1.7	1.5
	MG-4	-2.1	-2.9	-2.2	-3.1	-3.3	-2.9	-3.5	189.1	2.9	1.5	1.1	1.3	1.2	0.1	0.1	1.1
	MG-5	-3.7	-3.3	-3.5	-3.4	-5.1	-4.2	-3.9	185.3	-114.7	2.0	3.1	2.0	3.0	1.7	2.1	2.4
5 CLOSED	MG-1	-1.4	-0.4	-0.9	-1.6	-0.3	-1.0	-0.9	55.2	-44.3	-0.7	0.3	-0.2	-0.9	0.4	-0.3	-0.2
	MG-2	-0.0	-1.7	-1.3	-1.9	-1.1	-1.5	-1.4	46.1	60.0	-1.9	-2.0	-2.4	-3.0	-2.2	-2.6	-2.3
	MG-3	-2.6	-2.1	-2.3	-2.2	-1.7	-1.9	-2.1	119.9	11.6	1.5	2.1	1.0	1.9	2.5	2.2	2.0
	MG-4	-2.0	-2.0	-2.4	-2.5	-3.3	-2.9	-2.6	99.1	-255.2	0.7	1.6	1.1	1.0	0.7	0.6	0.9
	MG-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE B-8. DRIVEABILITY TEST DATA

CAR #	DRIVER	BASE	MG-1	MG-2	MG-3	MG-4	MG-5
04-1	HM	88	123	170	211	198	191
		62	101	60	197	143	145
	Average	75	112	115	204	170	168
04-2	RC	52	100	81	111	112	105
		46	67	78	68	88	64
	Average	49	84	80	90	100	84
04-3	FL	33	57	77	97	96	93
		46	79	112	88	110	116
	Average	40	68	94	92	103	104
04-4	HM	55	138	73	193	123	77
		48	117	78	194	185	97
	Average	52	128	76	194	154	87
06-1	FL	30	18	12	56	98	111
		12	32	30	66	182	159
	Average	21	25	21	61	140	135
C4-1	RC	91	93	144	154	148	191
		81	147	89	206	96	219
	Average	86	120	116	180	122	205
C4-2	PB	88	88	88	97	97	97
		54	74	92	120	86	110
	Average	76	81	90	108	92	103
C4-3	FL	12	24	18	86	94	94
		23	54	11	108	121	100
	Average	18	39	14	97	108	97
C4-4	RC	55	105	91	91	163	55
		36	79	84	98	128	98
	Average	46	92	88	94	146	76
C6-1	HM	41	77	98	107	71	156
		48	94	71	116	67	184
	Average	44	86	84	112	69	170

TABLE B-9. VAPOR LOCK TEST DATA

Soak-Speed Condition for Largest Percent Increase (Smallest Percent Decrease)
Relative to Base Acceleration Time

CAR #	BASE FUEL	MG-1	MG-2	MG-3	MG-4	MG-5
04-1	I-70/-5%	I-50/-2%	I-60/-3%	I-70/-5%	I-70/-4%	I-70/-4%
04-2	I-50/-4%	I-50/+1%	I-50/-2%	I-60/-4%	I-70/-5%	I-50/-2%
04-3	E-70/-4%	E-50/3%	I-50/7%	E-50/4%	E-50/-4%	E-70/6%
04-4	E-50/6%	E-50/4%	I-50/9%	E-59/14%	E-50/15%	E-60/4%
06-1	I-70/-21%	I-70/-33%	I-70/-22%	I-70/-30%	I-70/-25%	I-70/-10%
C4-1	I-70/-1%	I-60/2%	I-60/-3%	I-60/-3%	I-60/4%	I-60/3%
C4-2	I-70/-3%	I-50/-3%	I-60/4%	I-60/-4%	I-60/2%	I-60/2%
C4-3	E-50/5%	E-50/6%	E-50/3%	I-50/18%	E-70/5%	E-70/8%
C4-4	E-50/10%	E-50/3%	E-50/-4%	E-70/-1%	E-50/13%	E-50/11%
C6-1	I-70/-20%	I-60/-11%	I-70/-10%	I-70/-19%	I-79/-10%	I-60/-12%

NOTES: All tests run at $100^{o}F \pm 3^{o}F$
I = Idle Soak
E = Engine Off Soak
50 = 15-50 mph acceleration
60 = 15-60 mph acceleration
70 = 15-70 mph acceleration

CAR 04-1

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASE	1-3057	111081	6733	FTP	0.237	0.225	2.136	359.3	1.704	15.0	0	0.7	24.40	22.15	23.23	DIUR	0.586	0.534	11	62	2.1	11.6
4,2				HFET	0.052	0.052	0.029	267.8	2.146				33.10	32.64	32.87	HOT	1.037	0.975	11	76	1.1	7.8
1															27.56	TOTL	1.623	1.509	22	137	1.5	9.1
BASE	1-3174	10782	7670	FTP	0.133	0.123	1.933	357.0	1.573	13.4	0	0.4	24.71	24.03	24.37	DIUR	0.523	0.457	0	92	0	20.1
4,2				HFET	0.055	0.055	0.176	270.9	1.807				32.68	33.17	32.93	HOT	0.787	0.663	0	172	0	26.0
2															28.22	TOTL	1.310	1.120	0	264	0	23.6
MG-1	1-3060	111181	6751	FTP	0.161	0.151	1.816	370.4	1.881	13.5	0.3	0.4	23.48	22.44	22.95	DIUR	0.347	0.312	11	38	3.5	12.3
4,2				HFET	0.059	0.059	0.022	264.6	2.499				33.14	32.92	33.03	HOT	0.991	0.863	11	167	1.3	19.3
1															27.49	TOTL	1.338	1.175	22	205	1.9	17.4
MG-1	1-3172	10682	7608	FTP	0.142	0.135	1.050	362.8	1.808	8.9	0.3	0.4	24.05	24.41	24.23	DIUR	0.708	0.625	0	115	0	18.4
4,2				HFET	0.055	0.055	0.013	263.4	2.339				33.27	33.46	33.37	HOT	1.622	1.424	11	264	0.8	18.5
2															28.34	TOTL	2.330	2.050	11	379	0.5	18.5
MG-2	1-3077	111781	6786	FTP	0.241	0.229	2.081	365.1	1.651	14.4	0	1.7	24.04	22.95	23.48	DIUR	0.877	0.788	0	123	0	15.6
4,2				HFET	0.067	0.067	0.009	268.3	2.149				32.71	32.49	32.60	HOT	1.623	1.403	11	295	0.8	21.1
1															27.58	TOTL	2.500	2.191	11	419	0.5	19.1
MG-2	1-3088	112081	6835	FTP	0.151	0.142	1.101	360.1	1.891	11.1	0	1.1	24.38	23.87	24.12	DIUR	0.861	0.785	-11	116	-1.4	14.8
4,2				HFET	0.060	0.060	0.011	269.8	2.016				32.53	33.15	32.84	HOT	1.800	1.597	11	271	0.7	17.0
2															28.04	TOTL	2.661	2.382	0	387	0	16.3
MG-3	1-3070	111381	6766	FTP	0.206	0.187	1.717	349.4	2.200	24.1	0	1.6	23.93	22.42	23.15	DIUR	1.184	1.019	0	230	0	22.6
4,2				HFET	0.052	0.052	0.009	257.9	3.121				32.71	32.62	32.66	HOT	1.776	1.467	0	430	0	29.3
1															27.43	TOTL	2.960	2.485	0	660	0	26.5
MG-3	1-3176	10882	7713	FTP	0.105	0.100	0.308	345.3	2.176	1.5	0	4.6	24.38	24.66	24.52	DIUR	1.212	1.086	0	175	0	16.2
4,2				HFET	0.072	0.072	0.006	256.3	2.927				32.89	33.44	33.17	HOT	2.182	1.893	11	391	0.6	20.6
2															28.41	TOTL	3.394	2.979	11	566	0.4	19.0
MG-4	1-3094	112381	6849	FTP	0.202	0.185	2.644	363.5	2.061	13.1	0	8.5	22.95	22.09	22.51	DIUR	0.646	0.564	0	115	0	20.3
4,2				HFET	0.059	0.059	0.020	263.6	2.891				32.03	32.38	32.20	HOT	2.098	1.806	0	406	0	22.5
1															26.87	TOTL	2.744	2.369	0	521	0	22.0
MG-4	1-3169	10582	7549	FTP	0.153	0.142	1.092	353.2	2.090	11.1	0	3.2	23.77	24.18	23.98	DIUR	0.779	0.693	-11	130	-1.6	18.8
4,2				HFET	0.060	0.060	0.094	259.7	2.734				32.49	32.99	32.74	HOT	1.982	1.627	11	483	0.7	29.7
2															27.92	TOTL	2.761	2.320	-1	613	0	26.4
MG-5	1-3147	121881	7294	FTP	0.225	0.202	2.555	360.6	2.015	24.2	0	6.0	22.79	21.95	22.36	DIUR	0.750	0.664	0	120	0	18.1
4,2				HFET	0.031	0.031	0.004	258.3	2.802				32.22	31.96	32.09	HOT	2.081	1.728	0	490	0	28.4
1															26.74	TOTL	2.831	2.392	0	610	0	25.5
MG-5	1-3148	121881	7332	FTP	0.142	0.129	1.050	349.0	1.920	12.5	0	4.0	23.72	24.15	23.93	DIUR	0.875	0.748	0	177	0	23.6
4,2				HFET	0.040	0.040	-0.002	256.0	2.718				32.51	33.10	32.80	HOT	1.934	1.573	11	491	0.7	31.2
2															27.92	TOTL	2.809	2.321	11	668	0.5	28.8

CARR . 04-2

FUEL INTVL. TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NON-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASH	1-3058	111081	7225	FTP	0.326	0.321	2.570	387.4	1.163	7.1	0	0	22.60	22.70	22.65	DIUR	0.770	0.757	11	8	1.5	1.0
4.2				HFET	0.023	0.023	0.010	295.6	1.451				29.99	30.54	30.26	HOT	0.844	0.811	0	45	0	3.6
1															26.08	TOTL	1.614	1.568	11	53	0.7	3.4
BASH	1-3128	120981	7675	FTP	0.213	0.206	4.239	376.4	1.256	11.0	0	1.0	22.99	22.70	22.85	DIUR	0.818	0.807	0	15	0	1.9
4.2				HFET	0.018	0.018	0.058	282.9	1.796				31.16	31.75	31.45	HOT	0.958	0.950	-11	23	-1.2	2.4
2															26.72	TOTL	1.776	1.757	-11	38	-0.6	2.1
M6-1	1-3061	111181	7241	FTP	0.210	0.186	2.421	381.8	1.475	25.2	0	6.2	22.72	22.20	22.46	DIUR	0.525	0.490	11	38	2.2	7.8
4.2				HFET	0.053	0.053	0.007	278.8	2.146				31.56	31.68	31.62	HOT	1.057	0.974	0	113	0	11.6
1															26.58	TOTL	1.582	1.464	11	151	0.7	10.3
M6-1	1-3079	111881	7305	FTP	0.155	0.131	2.894	378.2	1.241	19.1	0	10.8	22.90	22.49	22.69	DIUR	0.681	0.615	0	92	0	14.9
4.2				HFET	0.040	0.040	0.010	285.8	1.813				30.71	31.80	31.24	HOT	1.487	1.308	0	248	0	15.9
2															26.54	TOTL	2.168	1.923	0	340	0	17.7
M6-2	1-3076	111781	7287	FTP	0.271	0.250	3.126	378.3	0.931	19.2	0	8.0	22.89	22.43	22.66	DIUR	0.689	0.573	0	162	0	28.3
4.2				HFET	0.051	0.051	0.001	283.2	2.411				31.02	31.81	31.41	HOT	1.313	1.311	-44	67	-5.0	5.1
1															26.40	TOTL	2.002	1.884	-44	229	-3.3	12.1
M6-2	1-3089	112081	7339	FTP	0.199	0.186	2.842	381.4	1.211	14.0	0	2.9	22.73	22.71	22.72	DIUR	0.847	0.704	0	198	0	28.2
4.2				HFET	0.021	0.021	0.005	281.1	2.183				31.25	32.01	31.62	HOT	1.583	1.360	11	300	0.8	22.0
2															26.73	TOTL	2.430	2.064	11	498	0.5	24.1
M6-3	1-3069	111381	7256	FTP	0.344	0.311	2.251	361.7	1.818	29.1	0	12.9	23.04	22.35	22.69	DIUR	0.769	0.670	0	138	0	20.6
4.2				HFET	0.052	0.052	-0.003	263.1	2.517				32.05	31.76	31.91	HOT	1.165	1.008	0	219	0	21.7
1															26.84	TOTL	1.934	1.677	0	357	0	21.3
M6-3	1-3085	111981	7324	FTP	0.288	0.271	3.119	377.1	1.971	15.3	0	7.1	22.01	22.17	22.09	DIUR	0.899	0.825	-11	114	-1.4	13.9
4.2				HFET	0.009	0.009	0.001	271.3	2.121				31.11	31.24	31.18	HOT	1.410	1.172	0	331	0	28.2
2															26.18	TOTL	2.309	1.997	-11	445	-0.6	22.3
M6-4	1-3111	121081	7690	FTP	0.285	0.258	2.476	360.3	1.799	29.3	0	6.4	23.15	22.64	22.89	DIUR	0.740	0.685	0	77	0	11.2
4.2				HFET	0.051	0.051	0.020	274.5	2.531				30.78	31.17	30.97	HOT	1.431	1.250	11	241	0.8	19.3
1															26.55	TOTL	2.171	1.935	11	318	0.5	16.4
M6-4	1-3136	121181	7706	FTP	0.296	0.273	3.523	370.6	2.021	20.3	0	9.7	22.43	21.94	22.18	DIUR	0.674	0.584	11	115	1.9	19.6
4.2				HFET	0.031	0.031	0.005	273.4	3.097				30.91	31.01	30.96	HOT	1.446	1.338	11	140	0.8	10.5
2															26.13	TOTL	2.120	1.922	22	255	1.1	13.2
M6-5	1-3139	121581	7719	FTP	0.297	0.274	2.828	376.2	2.096	23.9	0.3	5.7	21.82	22.29	22.05	DIUR	0.751	0.620	22	161	3.6	26.0
4.2				HFET	0.055	0.055	0.011	276.1	3.153				30.14	30.96	30.54	HOT	1.612	1.157	21	611	1.8	52.8
1															25.87	TOTL	2.363	1.777	43	772	2.4	43.5
M6-5	1-3175	10882	7855	FTP	0.209	0.201	2.286	375.5	2.109	6.0	0	4.0	21.72	22.18	21.94	DIUR	0.649	0.539	0	153	0	28.4
4.2				HFET	0.071	0.071	0.006	280.6	2.220				29.65	30.79	30.21	HOT	1.667	1.519	11	196	0.7	12.9
2															25.66	TOTL	2.316	2.057	11	349	0.5	17.0

CAR C4-1

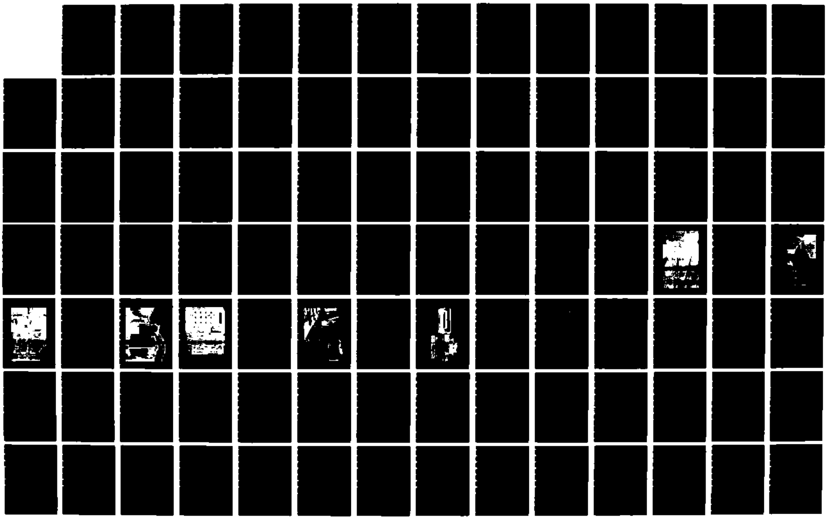
FUEL ENTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASH	1-2862	80481	6148	FTP	0.501	0.490	4.902	421.3********		15.1	0	-0.5	20.45	20.91	20.68	DIUR	0.592	0.589	-11	15	-1.9	2.6
4.2				HFET	0.022	0.022	0.025********		0.535				31.02	33.29	32.12	HOT	1.873	1.838	11	38	0.6	2.0
2															25.82	TOTL	2.465	2.427	0	53	0	2.2
BASH	1-2873	80781	6204	FTP	0.475	0.438	6.213	417.5	0.770	38.0	0	10.8	20.68	21.52	21.09	DIUR	1.840	1.813	0	38	0	2.1
4.2				HFET	0.013	0.013	0.037	249.0	0.825				32.88	33.56	33.21	HOT	2.031	1.983	0	67	0	3.4
3															26.55	TOTL	3.871	3.795	0	105	0	2.8
BASH	1-3165	123081	7450	FTP	0.256	0.227	11.156	389.6	0.706	29.9	0.4	7.7	21.58	21.90	21.74							
4.2				HFET	-0.001	-0.001	0.087	267.8	0.955				33.10	36.84	34.87							
4															27.65							
BASH	1-3167	123181	7490	FTP	0.248	0.238	3.555	369.6	0.793	11.2	1.4	1.0	23.59	24.01	23.80							
4.2				HFET	0.028	0.028	0.007	244.1	0.993				33.57	34.39	33.98							
5															28.38							
MG-1	1-2889	81481	6271	FTP	0.274	0.258	3.078	388.8	0.411	14.3	0	6.8	22.25	21.44	21.84	DIUR	1.106	1.016******		114*******		11.2
4.2				HFET	0.037	0.037	0.002	264.2	0.805				33.21	34.32	33.76	HOT	2.045	1.834	0	293	0	16.0
1															27.20	TOTL	3.151	2.850	11	407	0.4	14.3
MG-1	1-2895	81881	6322	FTP	0.329	0.315	3.478	404.2	0.874	12.4	0	5.2	21.37	21.51	21.44	DIUR	4.467	4.198	0	373	0	8.9
4.2				HFET	0.058	0.058*******		241.2	0.917				33.56	34.18	33.86	HOT	5.407	4.804	0	838	0	17.4
2															27.03	TOTL	9.874	9.002	0******		0******	
MG-1	1-2939	91181	6538	FTP	0.223	0.206	2.704	397.1	0.924	13.2	0	8.4	21.83	21.96	21.90	DIUR	1.512	1.385	0	176	0	12.7
4.2				HFET	0.029	0.029	0.005	262.2	0.999				33.46	34.38	33.91	HOT	5.935	5.764******		217******		3.8
4															27.30	TOTL	7.447	7.149	21	393	0.3	5.5
MG-2	1-2999	101581	6793	FTP	0.302	0.287	3.901	406.7	0.624	15.3	0	4.0	21.23	19.98	20.58	DIUR	1.360	1.150	0	292	0	25.3
4.2				HFET	-0.004	-0.004	0.015	273.2	0.432				32.15	33.12	32.63	HOT	3.113	2.056	0	1468	0	71.4
1															26.00	TOTL	4.473	3.206	0	1760	0	54.9
MG-2	1-3066	111281	6884	FTP	0.299	0.287	4.451	410.2	0.924	1.5	0	12.8	21.01	20.18	20.59	DIUR	1.465	1.327	0	192	0	14.5
4.2				HFET	-0.021	-0.021	0.105	288.8	0.972				30.41	32.93	31.62	HOT	6.816	5.879	0	1301	0	22.1
3															25.55	TOTL	8.281	7.206	0	1493	0	20.7
MG-3	1-2912	82881	6445	FTP	0.247	0.239	2.849	389.0	1.129	7.9	0	2.0	21.40	21.75	21.58	DIUR	2.647	2.313	11	453	0.5	19.6
4.2				HFET	0.024	0.024	0.002	258.8	1.954				32.40	33.32	32.95	HOT	8.557	7.202	21	1861	0.3	25.8
2															26.70	TOTL	11.204	9.515	32	2314	0.3	24.3
MG-3	1-2924	90381	6494	FTP	0.261	0.256	2.880	392.7	1.224	1.9	0	3.7	21.20	20.54	20.87	DIUR	2.517	2.260	-11	367	-0.5	16.3
4.2				HFET	0.030	0.030	0.040	259.1	2.201				32.55	33.45	32.99	HOT	5.314	4.443	11	1200	0.2	27.0
3															26.32	TOTL	7.831	6.703	-1	1568	0	23.4
MG-4	1-2946	91681	6588	FTP	0.307	0.281	3.206	390.3	1.328	29.0	0	5.6	21.32	21.07	21.20	DIUR	1.217	1.024	0	268	0	26.1
4.2				HFET	0.026	0.026	-0.001	256.3	2.107				32.96	33.63	33.29	HOT	10.752	8.733	43	2763	0.5	31.6
1															26.64	TOTL	11.969	9.757	43	3030	0.4	31.1
MG-4	1-2964	92581	6642	FTP	0.351	0.331	3.942	392.8	0.702	19.5	0	4.9	21.12	21.10	21.11	DIUR	0.964	0.810	0	214	0	26.5
4.2				HFET	0.029	0.029	0.009	258.5	1.259				32.67	33.53	33.10	HOT	10.660	8.858	22	2482	0.2	28.0
2															26.50	TOTL	11.624	9.668	21	2696	0.2	27.9
MG-5	1-2882	100781	6688	FTP	0.385	0.362	3.117	391.7	1.265	10.0	0	18.2	20.93	20.99	20.96	DIUR	1.047	0.839	0	289	0	34.5
4.2				HFET	0.023	0.023	0.019	256.5	1.834				32.45	33.12	32.78	HOT	7.455	6.301	43	1561	0.7	24.8
1															26.28	TOTL	8.502	7.140	43	1850	0.6	25.9
MG-5	1-2993	101381	6731	FTP	0.359	0.335	3.595	388.8	0.534	4.6	0	20.3	21.05	21.27	21.16	DIUR	1.087	0.905	0	252	0	27.9
4.2				HFET	0.007	0.007	0.003	253.8	0.755				32.80	33.14	32.97	HOT	9.519	7.980	32	2105	0.4	26.4
2															26.47	TOTL	10.606	8.886	32	2358	0.4	26.5

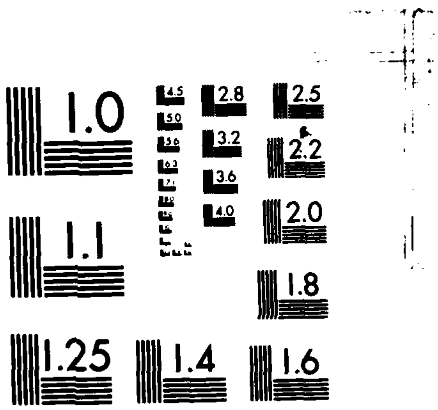
CAR C4-2

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASM	1-2747	61881	5882	FTP	0.456	0.440	4.823	407.1	0.566	20.6	0.4	1.1	21.29	21.28	21.28	DIUR	1.026	1.037	0	-15	0	-1.5
4,2				HFET	0.017	0.017	0.123	306.6	0.591				28.90	30.61	29.73	HOT	1.961	1.950	0	15	0	0.8
2															25.09	TOTL	2.987	2.987	0	0	0	0
BASM	1-2796	71481	5938	FTP	0.342	0.313	3.737	412.8	0.568	36.6	0	2.1	21.02	21.07	21.05	DIUR	0.392	0.363	11	30	3.0	8.4
4,2				HFET	0.019	0.019	0.243	308.3	0.564				28.69	29.94	29.30	HOT	1.303	1.305	-11	7	-0.8	0.6
3															24.76	TOTL	1.695	1.668	0	38	0	2.2
MG-1	1-2810	71781	5986	FTP	0.336	0.310	3.024	415.8	0.593	30.7	0	4.4	20.66	21.23	20.94	DIUR	0.709	0.627	0	114	0	18.2
4,2				HFET	0.036	0.036	2.957	323.0	0.522				27.17	29.49	28.29	HOT	3.142	2.931	11	283	0.4	9.6
1															24.25	TOTL	3.851	3.558	11	397	0.3	11.1
MG-1	1-2819	72181	6042	FTP	0.282	0.255	3.785	408.6	0.557	23.2	0	11.1	21.13	22.05	21.58	DIUR	0.751	0.672	11	99	1.6	14.7
4,2				HFET	0.026	0.026	0.913	319.3	0.431				27.49	30.16	28.76	HOT	3.915	3.464	22	606	0.6	17.5
2															24.81	TOTL	4.666	4.136	33	705	0.8	17.0
MG-2	1-2997	101481	6490	FTP	0.253	0.241	3.552	409.3	0.478	5.6	0	9.4	21.13	20.86	21.00	DIUR	1.182	1.058	11	161	1.0	15.2
4,2				HFET	-0.001	-0.001	0.227	323.1	0.585				27.14	30.13	28.54	HOT	3.640	3.009	22	855	0.7	28.4
1															24.40	TOTL	4.822	4.067	33	1016	0.8	25.0
MG-2	1-3007	102081	6537	FTP	0.381	0.356	3.792	412.0	0.672	18.6	0	13.3	20.96	20.95	20.96	DIUR	0.875	0.709	0	231	0	32.5
4,2				HFET	-0.001	-0.001	0.291	320.9	0.606				27.34	30.28	28.74	HOT	3.837	3.351	11	664	0.3	19.8
2															24.46	TOTL	4.712	4.060	11	895	0.3	22.0
MG-3	1-2851	72981	6124	FTP	0.261	0.244	2.827	398.6	0.599	15.5	0	6.7	20.91	21.00	20.96	DIUR	1.000	0.868	0	183	0	21.1
4,2				HFET	0.029	0.029	0.022	289.4	0.552				29.15	30.40	29.76	HOT	4.288	3.381	11	1250	0.3	37.0
1															24.92	TOTL	5.288	4.249	11	1433	0.2	33.7
MG-3	1-2858	73181	6174	FTP	0.340	0.311	2.470	396.9	0.608	28.4	0	9.2	21.03	21.74	21.38	DIUR	1.098	0.917	0	252	0	27.4
4,2				HFET	0.034	0.034	0.063	290.7	0.597				29.03	30.28	29.64	HOT	3.946	3.265	11	936	0.3	28.7
2															25.10	TOTL	5.044	4.182	11	1187	0.3	28.4
MG-4	1-2954	92281	6284	FTP	0.452	0.423	3.401	296.1	0.739	14.0	-0.9	22.2	20.94	21.38	21.16	DIUR	0.807	0.665	0	198	0	29.8
4,2				HFET	0.019	0.019	0.021	292.5	0.668				28.88	30.79	29.81	HOT	3.939	3.163	22	1057	0.7	33.4
1															25.05	TOTL	4.746	3.827	22	1255	0.6	32.8
MG-4	1-2962	92481	6364	FTP	0.431	0.401	3.715	396.0	0.517	7.4	1.1	27.3	20.96	21.20	21.08	DIUR	1.433	1.173	11	351	0.9	29.9
4,2				HFET	0.015	0.015	0.050	297.6	0.473				28.39	29.90	29.13	HOT	3.058	2.351	11	972	0.5	41.3
2															24.70	TOTL	4.491	3.523	22	1323	0.6	37.5
MG-5	1-2973	100181	6400	FTP	0.284	0.267	2.591	395.5	0.774	17.0	0	7.6	20.81	20.85	20.83	DIUR	1.376	1.159	11	290	0.9	25.0
4,2				HFET	0.036	0.036	0.007	284.0	0.785				29.32	30.30	29.80	HOT	6.694	5.441	43	1698	0.8	31.2
1															24.87	TOTL	8.070	6.600	54	1989	0.8	30.1
MG-5	1-2978	100681	6441	FTP	0.365	0.340	3.559	398.9	0.822	5.3	0	23.8	20.53	20.57	20.55	DIUR	1.250	1.025	0	313	0	30.5
4,2				HFET	0.016	0.016	-0.003	281.6	0.977				29.57	30.85	30.20	HOT	6.970	5.863	11	1528	0.2	26.1
2															24.89	TOTL	8.220	6.887	11	1841	0.2	26.7

AD-A159 893 PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBIL (U) COORDINATING RESEARCH COUNCIL INC ATLANTA GA JAN 84 CRC-536 DAAK70-81-C-0128 2/3

UNCLASSIFIED F/G 21/4 NL





CAR C6-1

FUEL					TAILPIPE EMISSIONS								FUEL ECONOMY			SHED						
INTVL	RUN	TEST	ODOM	TEST	REGULATED (GM/MI)					UNREG (MGM/MI)			(MILES/GALLON)			TEST	(GM HC)		(MGM)		PERCENT HC	
TEST	NUMBER	DATE	(MI)	TYPE	ORG-FID	HC	CO	CO2	NOX-C	ALD	ET-OH	ME-OH	CARBON	VOLUME	AVERAG	COND	ORG-FID	HC	ET-OH	ME-OH	ET-OH	ME-OH
DASH	1-2658	52181	5802	FTP	0.305	0.296	5.412	442.9	0.486	12.8	1.1	-1.6	19.60	19.14	19.37	DIUR	0.488	0.473	11	8	2.3	1.6
4.2				HFET	0.025	0.025*******		325.4	0.282				27.23	25.56	26.37	HOT	1.850	1.827	11	22	0.6	1.2
3															22.52	TOTL	2.338	2.301	22	30	0.9	1.3
DASH	1-2723	61081	5847	FTP	0.286	0.260	5.681	452.8	0.590	43.8	-2.2	-4.9	19.17	19.07	19.12	DIUR	0.731	0.728	-11	15	-1.5	2.1
4.2				HFET	0.030	0.030	0.198	350.7	0.313				25.26	25.10	25.18	HOT	1.565	1.515	11	59	0.7	3.9
4															21.85	TOTL	2.296	2.243	0	74	0	3.3
DASH	1-3162	122981	8285	FTP	0.458	0.421	9.774	446.2	0.860	49.3	0.4	1.3	19.15	19.40	19.28							
4.2				HFET	0.039	0.039	0.203	338.2	0.566				26.19	24.03	25.06							
6															21.88							
MG-1	1-2760	62981	5926	FTP	0.257	0.241	4.621	472.8	0.905	17.2	0	4.2	18.25	18.83	18.54	DIUR	0.417	0.343	11	91	3.2	26.6
4.2				HFET	0.024	0.024	0.101	345.2	0.607				25.41	25.47	25.44	HOT	1.975	1.799	0	245	0	13.6
1															21.64	TOTL	2.392	2.142	11	337	0.5	15.7
MG-1	1-2775	70781	5972	FTP	0.325	0.268	4.437	474.2	0.822	18.0	0	49.8	18.20	18.81	18.50	DIUR	0.615	0.539	0	106	0	19.7
4.2				HFET	0.026	0.026	0.105	344.2	0.530				25.48	24.67	25.07	HOT	2.347	2.105	11	326	0.5	15.5
2															21.46	TOTL	2.962	2.644	10	432	0.4	16.3
MG-2	1-3107	120181	8011	FTP	0.230	0.220	5.832	448.5	0.783	13.6	0	0.5	19.13	19.20	19.17	DIUR	0.776	0.660	0	162	0	24.5
4.2				HFET	0.025	0.025	0.135	339.3	0.566				25.87	25.79	25.83	HOT	2.538	2.144	22	527	1.0	24.6
1															22.16	TOTL	3.314	2.803	22	688	0.8	24.6
MG-2	2-4049	120381	8055	FTP	0.575	0.551	10.597	449.5	0.914	15.4	4.8	10.2	18.77	19.36	19.06	DIUR	1.046	0.895	11	199	1.2	22.2
4.2				HFET	0.034	0.034	0.215	336.8	0.467				26.05	22.64	24.22	HOT	2.816	2.615	11	268	0.4	10.3
2															21.38	TOTL	3.862	3.510	22	467	0.6	13.3
MG-3	1-2781	70881	6021	FTP	0.250	0.230	4.240	467.6	0.903	10.5	0	13.5	17.77	18.34	18.05	DIUR	0.926	0.787******		182******		23.1
4.2				HFET	0.028	0.028	0.080	338.3	0.625				24.93	24.86	24.89	HOT	3.698	3.234	21	624	0.7	19.3
1															21.13	TOTL	4.624	4.021	32	806	0.8	20.1
MG-3	1-2787	71081	6068	FTP	0.328	0.289	3.891	462.3	0.916	27.3	0	21.7	17.98	18.42	18.19	DIUR	0.849	0.658	0	266	0	40.5
4.2				HFET	0.030	0.030	0.123	338.3	0.627				24.93	25.23	25.08	HOT	2.745	2.269	21	640	0.9	28.2
2															21.29	TOTL	3.594	2.927	21	906	0.7	31.0
MG-3	1-2801	71581	6103	FTP	0.396	0.362	4.441	466.0	1.058	28.7	0	14.8	17.80	18.35	18.07	DIUR	0.719	0.517	0	280	0	54.2
4.2				HFET	0.049	0.049	0.414**************						24.18	24.36	24.27	HOT	2.257	1.776******		658******		37.0
3															20.86	TOTL	2.976	2.293	11	938	0.5	40.9
MG-4	1-3121	120881	8106	FTP	0.440	0.392	9.085	452.2	0.930	25.9	0.4	32.6	18.06	18.78	18.41	DIUR	0.905	0.756	0	207	0	27.4
4.2				HFET	0.012	0.012	0.119	338.7	0.551				24.94	22.79	23.82	HOT	3.037	2.479	11	765	0.4	30.9
1															20.84	TOTL	3.942	3.234	11	972	0.3	30.1
MG-4	1-3130	121081	8151	FTP	0.284	0.237	4.374	454.7	0.884	40.4	3.5	16.8	18.26	18.90	18.58	DIUR	1.136	0.936	-22	300	-2.4	32.1
4.2				HFET	0.022	0.022	0.189	336.1	0.523				25.12	22.99	24.01	HOT	3.195	2.548	11	888	0.4	34.9
2															21.02	TOTL	4.331	3.484	-12	1188	-0.3	34.1
MG-5	1-3134	121181	8196	FTP	0.332	0.274	4.575	459.8	0.932	55.0	0.4	20.1	17.79	18.26	18.02	DIUR	1.023	0.816	11	276	1.3	33.8
4.2				HFET	0.029	0.029	0.128	338.0	0.576				24.61	24.67	24.64	HOT	3.187	2.600	21	795	0.8	30.6
1															21.00	TOTL	4.210	3.416	32	1071	0.9	31.4
MG-5	1-3138	121581	8239	FTP	0.284	0.258	4.374	451.5	0.925	14.9	1.1	16.3	17.99	18.38	18.19	DIUR	1.025	0.724	11	408	1.5	56.3
4.2				HFET	0.036	0.036	0.212	335.4	0.528				24.79	23.17	23.95	HOT	3.276	2.404	21	1190	0.9	49.5
2															20.78	TOTL	4.301	3.128	32	1598	1.0	51.1

CAR 06-1

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS: REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD.	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED: TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASH	1-2679	52881	5637	FTP;	0.319	0.296	5.506	440.9	2.027	33.3	******	-3.1	19.68	19.13	19.40	DIUR;	1.906	1.903	-11	15	-0.6	0.8
4.2				HFET;	0.042	0.042	0.020	323.0	1.762				27.44	25.59	26.49	HOT;	2.051	2.051	0	0	0	0
3															22.59	TOTL;	3.957	3.954	******	15	******	0.4
BASH	' 2725	61181	5697	FTP;	0.338	0.322	5.595	445.4	1.233	26.4	0	-3.6	19.48	19.16	19.32	DIUR;	1.244	1.257	-11	-8	-0.9	-0.6
4.2				HFET;	0.048	0.048	0.034	333.4	1.172				26.58	24.56	25.53	HOT;	2.070	2.065	0	7	0	0.4
4															22.11	TOTL;	3.314	3.322	-11	-1	-0.3	0
BASH	1-2750	61981	5787	FTP;	0.395	0.376	5.551	473.3	1.759	24.6	0	1.1	18.35	18.94	18.64	DIUR;	0.678	0.693	******	0	******	0
4.2				HFET;	0.045	0.045	0.018	345.1	1.687				25.68	25.49	25.59	HOT;	1.913	1.884	******	30	******	1.6
5															21.77	TOTL;	2.591	2.578	-11	30	-0.4	1.1
MG-1	1-2756	62681	5834	FTP;	0.328	0.298	5.163	477.2	2.070	26.2	0	12.6	18.05	18.87	18.45	DIUR;	2.143	2.015	11	167	0.5	8.3
4.2				HFET;	0.039	0.039	0.027	349.3	1.764				25.12	24.84	24.98	HOT;	2.221	1.979	11	325	0.5	16.4
1															21.39	TOTL;	4.364	3.995	22	492	0.5	12.3
MG-1	1-2770	70181	5886	FTP;	0.357	0.327	5.635	470.6	1.790	19.1	0	17.9	18.26	19.00	18.62	DIUR;	1.155	1.048	-11	160	-1.1	15.2
4.2				HFET;	0.038	0.038	0.017	351.3	1.517				24.98	25.00	24.99	HOT;	2.738	2.391	21	461	0.9	19.3
2															21.49	TOTL;	3.893	3.439	10	621	0.3	18.0
MG-2	1-3111	120281	7554	FTP;	0.328	0.294	5.152	472.9	1.594	15.1	0.4	******	18.22	18.74	18.48	DIUR;	2.507	2.184	66	384	3.0	17.6
4.2				HFET;	0.035	0.035	-0.007	340.3	1.423				25.81	22.69	24.15	HOT;	3.384	2.916	11	640	0.4	21.9
1															21.03	TOTL;	5.891	5.100	77	1024	1.5	20.1
MG-2	2-4052	120381	7419	FTP;	0.426	0.390	5.809	467.3	1.557	33.8	0.8	11.7	18.38	18.67	18.53	DIUR;	2.538	2.303	11	315	0.5	13.7
4.2				HFET;	0.035	0.035	0.001	334.1	1.281				26.29	22.82	24.43	HOT;	3.648	3.095	21	747	0.7	24.1
2															21.18	TOTL;	6.186	5.399	32	1062	0.6	19.7
MG-2	1-3153	122281	7768	FTP;	0.403	0.364	5.452	465.8	1.531	39.3	1.2	11.0	18.47	18.90	18.68							
4.2				HFET;	0.030	0.030	-0.005	336.8	1.257				26.07	22.43	24.11							
3															21.13							
MG-3	1-2783	70981	5974	FTP;	0.453	0.394	4.071	481.5	1.702	25.7	0	45.1	17.25	17.80	17.52	DIUR;	1.263	1.094	22	214	2.0	19.5
4.2				HFET;	0.042	0.042	0.025	354.2	1.259				23.82	23.49	23.65	HOT;	2.873	2.312	21	759	0.9	32.8
1															20.28	TOTL;	4.136	3.405	43	973	1.3	28.6
MG-3	1-2807	71681	6025	FTP;	0.378	0.332	4.783	482.8	1.634	36.5	0	21.7	17.17	17.57	17.37	DIUR;	1.367	1.096	22	356	2.0	32.4
4.2				HFET;	0.037	0.037	-0.002	356.9	1.247				23.64	23.45	23.55	HOT;	2.848	2.296	21	747	0.9	32.5
2															20.15	TOTL;	4.215	3.391	43	1102	1.3	32.5
MG-4	1-3156	122381	7814	FTP;	0.388	0.342	5.170	463.3	1.399	37.8	0.8	19.7	17.88	17.99	17.94	DIUR;	1.981	1.692	11	391	0.6	23.1
4.2				HFET;	0.035	0.035	-0.007	337.0	0.991				25.07	21.64	23.23	HOT;	4.062	3.708	-11	502	-0.3	13.5
1															20.32	TOTL;	6.043	5.400	0	893	0	16.5
MG-4	1-3160	122981	7860	FTP;	0.344	0.303	4.248	462.4	1.367	42.3	0.4	11.5	17.97	18.17	18.07	DIUR;	1.418	1.192	0	313	0	26.3
4.2				HFET;	0.037	0.037	-0.005	335.0	1.022				25.22	21.81	23.39	HOT;	3.802	2.973	0	1152	0	38.7
2															20.46	TOTL;	5.220	4.166	0	1465	0	35.2
MG-5	1-3164	123081	7896	FTP;	0.394	0.356	5.209	470.7	1.279	32.5	1.5	14.9	17.34	17.35	17.35	DIUR;	1.682	1.451	-11	331	-0.8	22.8
4.2				HFET;	0.051	0.051	-0.003	347.7	0.764				23.94	21.18	22.47	HOT;	3.244	2.543	-22	996	-0.9	39.2
1															19.65	TOTL;	4.926	3.994	-33	1327	-0.8	33.2
MG-5	2-4084	123181	7943	FTP;	0.371	0.307	3.573	454.2	1.427	42.4	0.4	36.7	17.68	17.31	17.49	DIUR;	1.402	1.181	22	285	1.9	24.2
4.2				HFET;	0.037	0.037	-0.003	339.0	0.813				24.56	21.25	22.78	HOT;	3.295	3.004	-11	415	-0.4	13.8
4															19.87	TOTL;	4.697	4.185	11	700	0.3	16.7

CAR. 04-3

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS ORG-FID	REGULATED (GM/MI) HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASH	2-3826	20981	6100	FTP	0.149	0.150	3.455	484.2	0.916	3.8		0******	18.10	18.12	18.11	DIUR	2.289	2.278	0	15	0	0.7
4.2				HFET	0.027	0.027	0.089	338.8	1.532				26.16	25.68	25.92	HOT	2.452	2.452	0	0	0	0
1															21.62	TOTL	4.741	4.730	0	15	0	0.3
BASH	2-3840	21281	6155	FTP	0.199	0.191	3.070	465.9	0.943	9.8	0	1.3	18.82	18.47	18.64	DIUR	0.499	0.505	0******		0******	
4.2				HFET	0.029	0.029	0.056	337.2	1.635				26.29	25.50	25.89	HOT	2.391	2.378******		7******		0.3
2															21.90	TOTL	2.890	2.883******		0******		0
BASH	1-2874	80781	6296	FTP	0.182	0.156	3.419	490.0	0.661	33.9	0	1.1	17.88	17.93	17.90	DIUR	0.360	0.349	0	15	0	4.3
4.2				HFET	0.032	0.032	0.281	352.2	1.118				25.14	25.59	25.36	HOT	2.381	2.247	0******		0******	
5															21.26	TOTL	2.741	2.596	0	201	0	7.7
MG-1	1-2891	81481	6382	FTP	0.146	0.134	1.349	465.8	0.905	13.6	0	2.5	18.74	18.82	18.78	DIUR	1.325	1.226	0	138	0	11.2
4.2				HFET	0.031	0.031	0.051	345.5	1.288				25.39	25.96	25.67	HOT	3.933	3.631	11	408	0.3	11.2
1															21.88	TOTL	5.258	4.857	11	546	0.2	11.2
MG-1	1-2896	81881	6457	FTP	0.140	0.126	1.710	478.5	1.107	12.3	0	5.6	18.23	18.33	18.28	DIUR	1.598	1.450	0	205	0	14.2
4.2				HFET	0.031	0.031	0.019	345.3	1.747				25.41	26.42	25.91	HOT	4.731	4.019	11	978	0.3	24.3
2															21.71	TOTL	6.329	5.469	11	1184	0.2	21.6
MG-2	1-3016	102381	6600	FTP	0.212	0.200	2.726	488.5	0.991	14.1	0	2.2	17.80	18.81	18.29	DIUR	1.007	0.875	0	184	0	21.0
4.2				HFET	0.030	0.030	0.027	339.6	1.542				25.86	26.57	26.21	HOT	2.718	2.342	11	512	0.5	21.9
1															21.85	TOTL	3.725	3.216	11	696	0.3	21.6
MG-2	1-3022	102781	6662	FTP	0.180	0.163	2.622	475.4	0.688	17.3	0	4.6	18.30	18.47	18.38	DIUR	1.093	1.005	0	122	0	12.2
4.2				HFET	0.029	0.029	0.053	329.9	0.918				26.62	26.95	26.78	HOT	3.323	2.865	43	594	1.5	20.7
2															22.16	TOTL	4.416	3.870	43	717	1.1	18.5
MG-3	1-2900	82081	6508	FTP	0.135	0.133	1.330	466.7	1.096	0.8	0	1.4	17.99	18.30	18.14	DIUR	1.380	1.238	0	198	0	16.0
4.2				HFET	0.031	0.031	0.004	335.0	1.547				25.19	25.67	25.43	HOT	5.075	4.637	0	608	0	13.1
1															21.42	TOTL	6.455	5.875	0	806	0	13.7
MG-3	1-2903	82581	6557	FTP	0.180	0.160	1.959	467.5	1.430	23.3	0	3.2	17.91	18.18	18.05	DIUR	1.155	0.997	0	220	0	22.0
4.2				HFET	0.034	0.034	0	328.4	2.271				25.69	25.75	25.72	HOT	4.044	3.504	11	740	0.3	21.1
2															21.50	TOTL	5.199	4.500	11	960	0.2	21.3
MG-4	1-3026	102981	6714	FTP	0.213	0.202	2.069	458.5	0.858	4.6	0	8.8	18.27	18.51	18.39	DIUR	1.444	1.240	0	283	0	22.8
4.2				HFET	0.038	0.038	0.006	347.3	2.027				24.32	26.09	25.17	HOT	7.336	6.150	22	1627	0.4	26.4
1															21.44	TOTL	8.780	7.390	22	1910	0.3	25.8
MG-4	1-3046	110581	6853	FTP	0.319	0.310	1.828	456.3	1.222	2.8	0	30.0	18.36	18.43	18.39	DIUR	1.519	1.354	0	230	0	17.0
4.2				HFET	0.034	0.034	0.012	322.4	1.971				26.20	26.91	26.55	HOT	6.833	5.792	22	1425	0.4	24.6
2															22.06	TOTL	8.352	7.145	22	1655	0.3	23.2
MG-5	2-4020	110381	6774	FTP	0.251	0.228	2.178	445.4	1.571	16.8	0	12.5	18.52	18.33	18.42	DIUR	1.225	1.106	-11	176	-1.0	15.9
4.2				HFET	0.031	0.031	0.010	324.7	1.894				25.63	25.88	25.76	HOT	5.439	4.656	32	1056	0.7	22.7
1															21.72	TOTL	6.664	5.763	21	1231	0.4	21.4
MG-5	1-3043	110481	6810	FTP	0.276	0.242	1.509	450.3	1.549	21.4	0.4	20.2	18.36	18.09	18.22	DIUR	1.418	1.226	0	267	0	21.8
4.2				HFET	0.032	0.032	0.018	324.7	1.839				25.63	25.84	25.74	HOT	5.679	4.529	32	1566	0.7	34.6
2															21.60	TOTL	7.097	5.755	32	1833	0.6	31.8

CAR 04-4

FUEL INTVL. TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS: ORG-FID	REGULATED (GM/MI): HC	CO	CO2	NOX-C	UNREG (MGM/MI): ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON): CARBON	VOLUME	AVERAG	SHED: TEST COND	(GM HC): ORG-FID	HC	(MGM): ET-OH	ME-OH	PERCENT HC: ET-OH	ME-OH
BASH	2-3822	20581	6160	FTP	0.153	0.149	1.134	470.0	1.492	5.6	0	0	18.78	19.91	19.33	DIUR	0.903	0.903	0	0	0	0
4,2				HFET	0.043	0.043	0.075	332.6	2.460				26.65	27.10	26.87	HOT	2.678	2.678	0	0	0	0
1															22.72	TOTL	3.581	3.581	0	0	0	0
BASH	2-3837	21281	6225	FTP	0.281	0.276	2.939	469.5	1.363	9.9	1.0	-2.9	18.67	19.79	19.21	DIUR	0.973	0.973	0	0	0	0
4,2				HFET	0.041	0.041	0.096	329.9	2.310				26.86	27.33	27.09	HOT	2.458	2.455	-11	15	-0.4	0.6
2															22.76	TOTL	3.431	3.428	-11	15	-0.3	0.4
MG-1	1-2813	72081	6391	FTP	0.160	0.135	1.107	464.8	1.719	33.5	0	1.1	18.79	19.25	19.02	DIUR	1.052	0.822	0	320	0	39.0
4,2				HFET	0.038	0.038	0.022	329.7	2.384				26.61	26.99	26.80	HOT	2.788	2.270	64	658	2.8	29.0
1															22.52	TOTL	3.840	3.091	64	978	2.1	31.6
MG-1	1-2829	72381	6437	FTP	0.136	0.123	0.783	463.2	1.336	15.6	0	1.4	18.88	19.34	19.11	DIUR	1.054	0.890	0	228	0	25.6
4,2				HFET	0.037	0.037	0.012	332.8	1.823				26.36	26.99	26.67	HOT	3.141	2.837	21	402	0.8	14.2
2															22.51	TOTL	4.195	3.727	21	629	0.6	16.9
MG-2	1-3173	10782	7812	FTP	0.206	0.189	1.206	465.7	2.049	19.2	0	2.9	18.71	20.01	19.34	DIUR	1.319	1.247	0	100	0	8.1
4,2				HFET	0.086	0.086	0.009	327.0	2.563				26.87	26.85	26.86	HOT	3.254	2.988	22	348	0.7	11.7
1															22.72	TOTL	4.573	4.235	21	449	0.5	10.6
MG-2	1-3177	10882	7870	FTP	0.120	0.095	1.755	466.3	1.855	25.6	0	7.5	18.71	19.57	19.13	DIUR	0.886	0.886	0	0	0	0
4,2				HFET	0.052	0.052	0.011	320.8	2.398				27.38	27.00	27.19	HOT	2.897	2.897	0	0	0	0
2															22.76	TOTL	3.783	3.783	0	0	0	0
MG-3	1-2832	72481	6490	FTP	0.129	0.118	0.418	453.9	1.493	14.2	0	0.5	18.55	18.97	18.76	DIUR	1.080	0.954	0	175	0	18.3
4,2				HFET	0.033	0.033	0.006	325.9	1.582				25.89	26.26	26.07	HOT	3.747	3.238	0	707	0	21.8
1															22.05	TOTL	4.827	4.192	0	882	0	21.0
MG-3	1-2840	72781	6540	FTP	0.138	0.117	0.591	449.3	1.457	19.3	0	7.6	18.73	19.13	18.93	DIUR	1.077	0.940	0	190	0	20.2
4,2				HFET	0.034	0.034	0.005	324.2	1.615				26.02	26.28	26.15	HOT	3.360	2.917	11	604	0.4	20.7
2															22.18	TOTL	4.437	3.857	11	795	0.3	20.6
MG-4	1-2970	93081	6638	FTP	0.275	0.263	1.159	443.0	2.016	16.9	0	-0.2	18.96	18.76	18.86	DIUR	0.632	0.495	0	190	0	38.3
4,2				HFET	0.033	0.033	0.018	321.7	2.134				26.26	26.71	26.48	HOT	2.911	2.523	0	539	0	21.4
1															22.29	TOTL	3.543	3.018	0	729	0	24.2
MG-4	1-3179	11282	7920	FTP	0.196	0.179	0.698	449.8	1.739	17.5	0	4.3	18.74	18.50	18.62	DIUR	1.266	1.266	0	0	0	0
4,2				HFET	0.031	0.031	0.006	326.5	2.261				25.99	26.44	26.21	HOT	3.688	3.687	0	1	0	0
2															22.04	TOTL	4.954	4.953	0	1	0	0
MG-5	1-3168	10582	6685	FTP	0.162	0.149	0.874	446.0	1.980	13.6	0.7	3.2	18.47	19.11	18.89	DIUR	1.206	1.096	0	153	0	13.9
4,2				HFET	0.034	0.034	-0.003	320.3	1.777				25.99	25.86	25.93	HOT	2.893	2.557	0	467	0	18.2
1															22.05	TOTL	4.099	3.653	0	619	0	17.0
MG-5	1-3171	10682	7754	FTP	0.096	0.085	0.148	445.9	1.781	14.6	0	0.5	18.26	18.96	18.61	DIUR	1.276	1.103	11	230	1.0	20.8
4,2				HFET	0.034	0.034	-0.003	318.5	1.775				26.14	26.05	26.09	HOT	9.738	8.379	21	1866	0.3	22.3
2															21.98	TOTL	11.014	9.482	32	2096	0.3	22.1

CAR C4-3

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	SHED TEST COND	(GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASH	1-2882	81281	7226	FTP	0.505	0.498	8.362	466.4	0.478	6.1	0	2.9	18.43	18.89	18.46	DIUR	1.792	1.754	0	53	0	3.0
4.2				HFET	0.137	0.137	0.320	339.7	0.395				26.03	26.54	26.29	HOT	1.128	1.115	11	7	0.9	0.6
1															22.09	TOTL	2.920	2.849	10	61	0.4	2.1
BASH	1-2898	81981	7287	FTP	0.503	0.499	8.166	453.3	0.588	8.4	0.2	-2.3	18.96	19.03	19.00	DIUR	2.099	2.094	0	7	0	0.4
4.2				HFET	0.077	0.077	0.177	329.3	0.443				26.89	27.02	26.95	HOT	3.123	3.125	-11	7	-0.3	0.2
2															22.58	TOTL	5.222	5.219	-11	15	-0.2	0.3
MG-1	1-2921	90281	7358	FTP	0.501	0.486	7.593	461.2	0.632	14.4	0	4.8	18.49	18.87	18.68	DIUR	1.634	1.445	25	238	1.7	16.5
4.2				HFET	0.060	0.060	0.071	336.6	0.522				26.04	26.38	26.22	HOT	5.078	4.747	21	439	0.5	9.2
1															22.07	TOTL	6.712	6.193	46	676	0.7	10.9
MG-1	1-3110	120281	8135	FTP	0.322	0.308	4.190	460.1	0.691	14.9	0.8	3.2	18.77	19.29	19.02	DIUR	1.754	1.583	0	237	0	15.0
4.2				HFET	0.049	0.049	0.063	327.5	0.525				26.78	27.01	26.89	HOT	4.285	4.016	22	352	0.5	8.8
3															22.57	TOTL	6.039	5.599	22	590	0.4	10.5
MG-2	1-3065	111281	7921	FTP	0.378	0.361	5.400	464.7	0.706	11.0	0	9.6	18.83	19.32	19.07	DIUR	2.091	1.876	0	299	0	16.0
4.2				HFET	0.074	0.074	0.073	333.7	0.487				26.29	26.79	26.54	HOT	4.957	4.174	11	1077	0.3	25.8
1															22.43	TOTL	7.048	6.049	11	1377	0.2	22.8
MG-2	1-3084	111981	7967	FTP	0.338	0.328	5.470	456.3	0.628	10.0	0	3.2	18.85	19.16	19.00	DIUR	1.719	1.542	0	246	0	15.9
4.2				HFET	0.068	0.068	0.062	322.9	0.462				27.18	27.18	27.18	HOT	4.907	4.692	22	278	0.5	5.9
2															22.68	TOTL	6.626	6.234	22	524	0.3	8.4
MG-3	1-2988	100981	7547	FTP	0.520	0.509	4.142	447.4	0.833	8.8	0	5.3	18.53	19.15	18.83	DIUR	1.564	1.348	11	290	0.8	21.5
4.2				HFET	0.059	0.059	0.054	323.4	0.610				26.06	26.17	26.11	HOT	11.932	10.243	43	2304	0.4	22.5
2															22.11	TOTL	13.496	11.591	54	2594	0.5	22.4
MG-3	2-4048	120381	8172	FTP	0.407	0.397	3.790	446.5	0.661	4.3	0.4	7.3	18.60	19.16	18.88	DIUR	1.867	1.652	0	299	0	18.1
4.2				HFET	0.068	0.068	0.059	321.3	0.502				26.24	26.03	26.14	HOT	10.933	9.499	22	1971	0.2	20.7
3															22.14	TOTL	12.800	11.151	22	2270	0.2	20.4
MG-4	1-3097	112481	8009	FTP	0.342	0.329	4.245	460.2	0.719	7.2	0.4	8.5	18.06	18.50	18.27	DIUR	1.874	1.627	0	343	0	21.1
4.2				HFET	0.062	0.062	0.055	333.4	0.501				25.32	25.93	25.62	HOT	18.729	15.629	43	4263	0.3	27.3
1															21.58	TOTL	20.603	17.256	43	4607	0.2	26.7
MG-4	1-3106	120181	8078	FTP	0.504	0.477	6.065	449.4	0.760	23.7	0.4	10.5	18.35	18.99	18.66	DIUR	1.914	1.634	0	389	0	23.8
4.2				HFET	0.071	0.071	0.055	328.0	0.535				25.74	26.10	25.92	HOT	14.989	12.184	43	3854	0.4	31.6
2															21.93	TOTL	16.903	13.818	43	4243	0.3	30.7
MG-5	1-2996	101481	7596	FTP	0.357	0.337	2.202	444.8	0.733	13.5	0	10.9	18.53	19.12	18.82	DIUR	2.109	1.827	0	391	0	21.4
4.2				HFET	0.045	0.045	0.029	338.2	0.485				24.61	25.36	21.98	HOT	17.578	13.377	43	5792	0.3	43.3
1															21.59	TOTL	19.687	15.204	43	6184	0.3	40.7
MG-5	1-3002	101681	7643	FTP	0.431	0.412	2.400	456.2	0.725	12.0	0	11.7	18.05	18.50	18.27	DIUR	2.377	2.027	11	476	0.5	23.5
4.2				HFET	0.045	0.045	0.029	327.9	0.513				25.38	25.70	25.54	HOT	17.214	12.974	86	5805	0.7	44.7
2															21.54	TOTL	19.591	15.001	97	6281	0.6	41.9

CAR. C4 ---- 4

FUEL INTVL TEST	RUN NUMBER	TEST DATE	ODOM (MI)	TEST TYPE	TAILPIPE EMISSIONS REGULATED (GM/MI) ORG-FID	HC	CO	CO2	NOX-C	UNREG (MGM/MI) ALD	ET-OH	ME-OH	FUEL ECONOMY (MILES/GALLON) CARBON	VOLUME	AVERAG	TEST COND	SHED (GM HC) ORG-FID	HC	(MGM) ET-OH	ME-OH	PERCENT HC ET-OH	ME-OH
BASM	1-2887	81381	6173	FTP	0.392	0.372	3.067	480.4	0.644	21.3	0	5.2	18.23	18.71	18.47	DIUR	1.090	1.079	0	15	0	1.4
4.2				HFET	0.059	0.059	0.063	343.3	0.373				25.82	26.08	25.95	HOT	2.597	2.579	11	15	0.4	0.6
1															21.84	TOTL	3.687	3.658	11	30	0.3	0.8
BASM	1-2897	81881	6272	FTP	0.343	0.329	2.746	477.1	0.756	16.6	0	2.1	18.38	18.83	18.60	DIUR	1.235	1.235	0	0	0	0
4.2				HFET	0.079	0.079	0.239	340.6	0.318				25.99	25.66	25.82	HOT	2.648	2.638	0	15	0	0.6
2															21.85	TOTL	3.883	3.873	0	15	0	0.4
MG-1	1-2917	90181	6369	FTP	0.265	0.238	1.810	481.1	0.858	29.2	0	6.9	18.10	18.56	18.33	DIUR	1.411	1.318	0	130	0	9.8
4.2				HFET	0.050	0.050	0.044	344.2	0.432				25.48	25.91	25.70	HOT	3.332	3.089	11	328	0.3	10.6
1															21.65	TOTL	4.743	4.406	11	457	0.2	10.4
MG-1	1-2943	91581	6419	FTP	0.317	0.300	2.355	475.7	0.781	10.3	0	10.8	18.27	18.65	18.46	DIUR	1.368	1.226	0	197	0	16.1
4.2				HFET	0.044	0.044	0.061	344.7	0.451				25.44	25.76	25.60	HOT	3.515	3.161	0	492	0	15.6
2															21.67	TOTL	4.883	4.387	0	689	0	15.7
MG-2	1-3000	101581	6794	FTP	0.315	0.307	2.559	484.6	0.978	9.4	0	0.9	17.94	18.49	18.21	DIUR	1.700	1.496	0	284	0	19.0
4.2				HFET	0.057	0.057	0.056	342.3	0.560				25.64	26.32	25.98	HOT	3.203	2.895	0	428	0	14.8
1															21.71	TOTL	4.903	4.391	0	712	0	16.2
MG-2	2-4002	101981	6845	FTP	0.299	0.284	2.159	473.2	0.774	19.0	0	1.5	18.39	18.82	18.60	DIUR	1.779	1.581	0	275	0	17.4
4.2				HFET	0.065	0.065	0.080	338.3	0.469				25.94	25.85	25.90	HOT	2.981	2.689	0	405	0	15.1
2															21.89	TOTL	4.760	4.270	0	681	0	15.9
MG-3	1-2949	91881	6468	FTP	0.289	0.275	1.732	467.9	0.808	12.3	0	5.6	17.90	18.21	18.05	DIUR	1.471	1.280	-1	266	-0.1	20.8
4.2				HFET	0.047	0.047	0.048	339.9	0.489				24.81	25.11	24.96	HOT	4.108	3.587	22	703	0.6	19.6
1															21.16	TOTL	5.579	4.867	21	969	0.4	19.9
MG-3	1-2961	92481	6532	FTP	0.292	0.254	1.616	470.2	0.623	12.5	0	32.9	17.82	18.03	17.93	DIUR	1.396	1.187	0	291	0	24.5
4.2				HFET	0.051	0.051	0.048	338.4	0.340				24.93	25.28	25.10	HOT	3.514	2.874	11	878	0.4	30.5
2															21.16	TOTL	4.910	4.061	11	1169	0.3	28.8
MG-4	1-2968	92981	6587	FTP	0.224	0.191	1.477	477.5	0.654	22.0	0	18.7	17.59	17.98	17.78	DIUR	1.822	1.394	0	594	0	42.6
4.2				HFET	0.035	0.035	0.035	335.6	0.490				25.17	25.34	25.26	HOT	3.893	3.534	22	477	0.6	13.5
1															21.14	TOTL	5.715	4.929	22	1071	0.4	21.7
MG-4	1-2974	100281	6646	FTP	0.244	0.213	2.047	463.1	0.918	4.9	0	31.0	18.09	18.45	18.27	DIUR	2.011	1.681	0	459	0	27.3
4.2				HFET	0.038	0.038	0.036	341.8	0.471				24.71	25.38	25.04	HOT	5.509	4.741	11	1056	0.2	22.3
2															21.32	TOTL	7.520	6.422	11	1515	0.2	23.6
MG-5	1-2985	100881	6688	FTP	0.238	0.208	1.742	464.9	0.906	16.0	0	21.0	17.78	18.04	17.91	DIUR	1.633	1.398	0	327	0	23.4
4.2				HFET	0.023	0.023	0.016	334.3	0.503				24.90	25.01	24.96	HOT	4.093	3.505	11	807	0.3	23.0
1															21.08	TOTL	5.726	4.902	11	1133	0.2	23.1
MG-5	1-2992	101381	6742	FTP	0.177	0.163	1.261	463.6	1.173	1.5	0	14.0	17.86	18.03	17.95	DIUR	1.686	1.320	11	498	0.8	37.7
4.2				HFET	0.033	0.033	0.027	332.4	0.526				25.04	24.65	24.55	HOT	3.826	3.229	11	818	0.3	25.3
2															21.05	TOTL	5.512	4.549	22	1316	0.5	28.9

TABLE B-10. DATA USED FOR ANALYSES OF VARIANCE CALCULATIONS

CAR MODEL=C CAR GROUP=CLOSED

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
1	C6-1	BASE	0.305	5.412	0.486	12.8	-1.6	2.338	0.0298	41	-10.8	22.0071	191.533
2	C6-1	BASE	0.286	5.681	0.590	43.8	-4.9	2.296	0.0740	48	-28.9	21.4521	186.702
3	C6-1	02BO	0.230	5.832	0.783	13.6	0.5	3.314	0.6884	98	-4.9	21.6128	187.286
4	C6-1	02BO	0.575	10.597	0.914	15.4	10.2	3.862	0.4673	71	-13.4	21.0161	182.115
5	C6-1	02B1	0.257	4.621	0.905	17.2	4.2	2.392	0.3366	77	-14.3	21.2318	186.081
6	C6-1	02B1	0.325	4.437	0.822	18.0	49.8	2.962	0.4319	94	-6.9	21.0909	184.846
7	C6-1	05BO	0.440	9.085	0.930	25.9	32.6	3.942	0.9724	71	-6.8	20.5914	186.011
8	C6-1	05BO	0.284	4.374	0.884	40.4	16.8	4.331	1.1883	67	-13.0	20.7683	187.609
9	C6-1	05B3	0.250	4.240	0.903	10.5	13.5	4.624	0.8062	107	-19.5	20.5909	186.512
10	C6-1	05B3	0.328	3.891	0.916	27.3	21.7	3.594	0.9059	116	-18.9	20.7505	187.957
11	C6-1	08B2	0.332	4.575	0.932	55.0	20.1	4.210	1.0713	156	-9.3	20.5470	190.780
12	C6-1	08B2	0.284	4.374	0.925	14.9	16.3	4.301	1.5977	184	-14.3	20.4420	189.805

CAR MODEL=C CAR GROUP=OPEN

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
13	O6-1	BASE	0.319	5.506	2.027	33.3	-3.1	3.957	0.0151	30	-16.3	22.0669	192.053
14	O6-1	BASE	0.338	5.595	1.233	26.4	-3.6	3.314	-0.0005	12	-25.8	21.7068	188.919
15	O6-1	02BO	0.328	5.152	1.594	15.1	11.0	5.891	1.0239	12	-15.4	20.5964	178.478
16	O6-1	02BO	0.426	5.809	1.557	33.8	11.7	6.186	1.0621	30	-28.6	20.7210	179.558
17	O6-1	02B1	0.328	5.163	2.070	26.2	12.6	4.364	0.4922	18	-30.4	21.0227	184.248
18	O6-1	02B1	0.357	5.635	1.790	19.1	17.9	3.893	0.6207	32	-26.9	21.1495	185.359
19	O6-1	05BO	0.388	5.170	1.399	37.8	19.7	6.043	0.8927	98	-17.7	20.0671	181.275
20	O6-1	05BO	0.344	4.248	1.367	42.3	11.5	5.220	1.4649	183	-30.1	20.2126	182.589
21	O6-1	05B3	0.453	4.071	1.702	25.7	45.1	4.136	0.9727	56	-33.7	19.8258	179.581
22	O6-1	05B3	0.378	4.783	1.634	36.5	21.7	4.215	1.1021	66	-26.0	19.6846	178.302
23	O6-1	08B2	0.394	5.209	1.279	32.5	14.9	4.926	1.3266	111	-13.6	19.3743	179.891
24	O6-1	08B2	0.371	3.573	1.427	42.4	36.7	4.697	0.7000	159	-6.3	19.5760	181.764

CAR MODEL=O CAR GROUP=CLOSED

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
25	C4-1	BASE	0.501	6.902	0.706	15.1	-0.5	2.465	0.0528	91	1.2	24.6375	214.426
26	C4-1	BASE	0.475	6.213	0.770	38.0	10.8	3.871	0.1050	81	-3.9	25.2515	219.770
27	C4-1	02BO	0.302	3.901	0.624	15.3	4.0	4.473	1.7597	144	-0.3	24.6041	213.207
28	C4-1	02BO	0.299	4.451	0.924	1.5	12.8	8.281	1.4933	89	-4.9	24.3414	210.930
29	C4-1	02B1	0.274	3.078	0.611	14.3	6.8	3.151	0.4069	93	4.8	26.1049	228.789
30	C4-1	02B1	0.223	2.704	0.924	13.2	8.4	7.447	0.3928	147	-0.3	25.8207	226.298
31	C4-1	05BO	0.307	3.206	1.328	29.0	5.6	11.969	3.0304	148	-0.3	25.4464	229.868
32	C4-1	05BO	0.351	3.942	0.702	19.5	6.9	11.624	2.6962	96	7.8	25.3264	228.784
33	C4-1	05B3	0.247	2.849	1.129	7.9	2.0	11.204	2.3144	154	-2.4	25.5354	231.299
34	C4-1	05B3	0.261	2.880	1.224	1.9	3.7	7.831	1.5675	206	-3.0	24.9921	226.378
35	C4-1	08B2	0.385	3.117	1.265	10.0	18.2	8.502	1.8498	191	2.7	25.0768	232.839
36	C4-1	08B2	0.359	3.595	0.534	6.6	20.3	10.606	2.3577	219	2.7	25.2853	234.776
37	C4-2	BASE	0.456	4.823	0.566	20.6	1.1	2.987	-0.0004	86	-2.0	24.4181	212.516
38	C4-2	BASE	0.342	3.737	0.568	36.6	2.1	1.695	0.0375	65	-4.0	24.1166	209.892
39	C4-2	02BO	0.253	3.552	0.678	5.6	9.4	4.822	1.0164	88	-4.0	23.7591	205.885
40	C4-2	02BO	0.381	3.792	0.672	18.6	13.3	4.712	0.8946	92	-1.0	23.7835	206.096
41	C4-2	02B1	0.336	5.024	0.593	30.7	4.4	3.851	0.3966	88	-3.8	23.8456	208.988
42	C4-2	02B1	0.282	3.785	0.557	23.2	11.1	4.666	0.7046	74	-2.0	24.4474	214.263

TABLE B-10. DATA USED FOR ANALYSES OF VARIANCE CALCULATIONS - (Continued)

CAR MODEL=O CAR GROUP=CLOSED

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
43	C4-2	05B0	0.452	3.401	0.739	14.0	22.2	4.746	1.2550	97	3.0	24.4391	220.769
44	C4-2	05B0	0.431	3.715	0.517	7.4	27.3	4.491	1.3227	86	2.0	24.1727	218.362
45	C4-2	05B3	0.261	2.827	0.599	15.5	6.7	5.288	1.4331	97	-3.8	24.1650	218.886
46	C4-2	05B3	0.340	2.470	0.608	28.4	9.2	5.044	1.1873	120	-6.0	24.4375	221.354
47	C4-2	08B2	0.286	2.591	0.774	17.0	7.6	8.070	1.9886	96	1.9	24.1509	224.243
48	C4-2	08B2	0.365	3.559	0.822	5.3	23.8	8.220	1.8405	110	-3.0	24.0559	223.360

CAR MODEL=O CAR GROUP=OPEN

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
49	O4-1	BASE	0.237	2.136	1.704	15.0	0.7	1.623	0.1374	88	-5.2	26.7715	232.998
50	O4-1	BASE	0.133	1.933	1.573	13.4	0.4	1.310	0.2640	62	-4.5	27.6100	240.296
51	O4-1	02B0	0.241	2.081	1.651	14.4	1.7	2.500	0.4185	170	-3.5	26.7770	232.036
52	O4-1	02B0	0.151	1.101	1.891	11.1	1.1	2.661	0.3874	60	-2.5	27.3036	236.600
53	O4-1	02B1	0.161	1.816	1.881	13.5	0.4	1.338	0.2050	123	3.5	26.7470	234.418
54	O4-1	02B1	0.142	1.050	1.808	8.9	0.4	2.330	0.3791	101	-7.4	27.7879	243.540
55	O4-1	05B0	0.202	2.644	2.061	13.1	8.5	2.744	0.5207	198	-2.1	26.1429	236.160
56	O4-1	05B0	0.153	1.092	2.090	11.1	3.2	2.761	0.6131	143	-6.0	27.3750	247.290
57	O4-1	05B3	0.206	1.717	2.200	24.1	1.6	2.960	0.6595	211	-4.3	26.6291	241.206
58	O4-1	05B3	0.105	0.308	2.176	1.5	4.6	3.394	0.5661	197	-5.8	27.7670	251.513
59	O4-1	08B2	0.225	2.555	2.035	24.2	6.0	2.831	0.6100	191	-5.5	25.9545	240.989
60	O4-1	08B2	0.142	1.050	1.920	12.5	4.0	2.809	0.6675	145	-3.3	27.3101	253.575
61	O4-2	BASE	0.326	2.570	1.163	7.1	0.0	1.614	0.0528	52	-4.0	25.5557	222.417
62	O4-2	BASE	0.215	4.239	1.256	11.0	1.0	1.776	0.0377	46	-3.0	26.0703	226.895
63	O4-2	02B0	0.271	3.126	0.931	19.2	8.0	2.002	0.2288	81	-4.0	25.8210	223.752
64	O4-2	02B0	0.199	2.842	1.211	14.0	2.9	2.430	0.4978	78	-1.0	25.9327	224.720
65	O4-2	02B1	0.210	2.421	1.475	25.2	6.2	1.582	0.1509	100	4.0	25.9640	227.554
66	O4-2	02B1	0.155	2.894	1.241	19.1	10.8	2.168	0.3399	67	-2.0	26.0219	228.062
67	O4-2	05B0	0.285	2.476	1.799	29.3	6.4	2.171	0.3181	112	-4.0	26.0443	235.269
68	O4-2	05B0	0.296	3.523	2.021	20.3	9.7	2.120	0.2545	88	-6.0	25.5315	230.637
69	O4-2	05B3	0.344	2.251	1.818	29.1	12.9	1.934	0.3566	111	-3.8	26.0681	236.124
70	O4-2	05B3	0.288	3.119	1.971	15.3	7.1	2.309	0.4449	68	-5.0	25.4137	230.197
71	O4-2	08B2	0.297	2.828	2.096	23.9	5.7	2.363	0.7721	105	0.0	25.2648	234.585
72	O4-2	08B2	0.209	2.286	2.109	6.0	4.0	2.316	0.3490	64	-3.0	25.0833	232.900

CAR MODEL=P CAR GROUP=CLOSED

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
73	C4-3	BASE	0.505	8.362	0.478	6.1	2.9	2.920	0.0605	12	8.0	21.4729	186.883
74	C4-3	BASE	0.503	8.166	0.588	8.4	-2.3	5.222	0.0147	23	2.0	21.9195	190.770
75	C4-3	02B0	0.378	5.400	0.706	11.0	9.6	7.048	1.3766	18	-5.0	21.7642	188.597
76	C4-3	02B0	0.338	5.470	0.628	10.0	3.2	6.626	0.5238	11	10.0	21.9046	189.814
77	C4-3	02B1	0.501	7.593	0.632	14.4	4.8	6.712	0.6764	24	10.5	21.5717	189.059
78	C4-3	02B1	0.322	4.190	0.691	14.9	3.2	6.039	0.5895	54	1.0	22.0296	193.073
79	C4-3	05B0	0.342	4.245	0.719	7.2	8.5	20.603	4.6068	94	2.4	21.0712	190.345
80	C4-3	05B0	0.504	6.065	0.760	23.7	10.5	16.903	4.2432	121	7.0	21.4439	193.712
81	C4-3	05B3	0.520	4.142	0.833	8.8	5.3	13.496	2.5939	86	25.7	21.5255	194.978
82	C4-3	05B3	0.407	3.790	0.661	4.3	7.3	12.800	2.2695	108	10.5	21.5646	195.332
83	C4-3	08B2	0.357	2.202	0.733	13.5	10.9	19.687	6.1838	94	1.3	21.2189	197.019
84	C4-3	08B2	0.431	2.400	0.725	12.0	11.7	19.591	6.2810	100	15.0	21.0026	195.010

TABLE B-10. DATA USED FOR ANALYSES OF VARIANCE CALCULATIONS - (Continued)

CAR MODEL=P CAR GROUP=CLOSED

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
85	C4-4	BASE	0.392	3.067	0.644	21.3	5.2	3.687	0.0299	55	0.5	21.2348	184.811
86	C4-4	BASE	0.343	2.746	0.756	16.6	2.1	3.883	0.0145	36	19.8	21.2930	185.318
87	C4-4	02B0	0.315	2.559	0.978	9.4	0.9	4.903	0.7115	91	-10.4	20.9744	181.754
88	C4-4	02B0	0.299	2.159	0.774	19.0	1.5	4.760	0.6806	84	3.5	21.2341	184.005
89	C4-4	02B1	0.265	1.810	0.858	29.2	6.9	4.743	0.4571	105	3.9	21.1627	185.475
90	C4-4	02B1	0.317	2.355	0.781	10.3	10.8	4.883	0.6894	79	1.0	21.2242	186.014
91	C4-4	05B0	0.224	1.477	0.654	22.0	18.7	5.715	1.0710	163	11.9	20.5992	186.081
92	C4-4	05B0	0.244	2.047	0.918	4.9	31.0	7.520	1.5148	128	14.1	20.8883	188.693
93	C4-4	05B3	0.289	1.732	0.808	12.3	5.6	5.579	0.9688	91	-0.7	20.6134	186.715
94	C4-4	05B3	0.292	1.616	0.623	12.5	32.9	4.910	1.1689	98	-2.1	20.5646	186.273
95	C4-4	08B2	0.238	1.742	0.906	16.0	21.0	5.726	1.1334	55	17.9	20.5604	190.904
96	C4-4	08B2	0.177	1.261	1.173	1.5	14.0	5.512	1.3161	98	4.5	20.5567	190.870

CAR MODEL=P CAR GROUP=OPEN

OBS	CARCODE	FUEL	ORGANIC	CO	NOX	ALDEHYDE	METHANOL	SHEDORG	SHEDMEOH	DEMERITS	VAPLOCK	MPGCOMB	ENECOMB
97	04-3	BASE	0.199	3.070	0.943	9.8	1.3	2.890	-0.0004	33	-1.3	20.9584	182.405
98	04-3	BASE	0.182	3.419	0.661	33.9	1.1	2.741	0.2010	46	-6.4	21.3385	185.714
99	04-3	02B0	0.212	2.726	0.991	14.1	2.2	3.725	0.6959	77	-4.3	21.0992	182.835
100	04-3	02B0	0.180	2.622	0.688	17.3	4.6	4.416	0.7167	112	18.0	21.3345	184.874
101	04-3	02B1	0.146	1.349	0.905	13.6	2.5	5.258	0.5460	57	2.5	21.4790	188.247
102	04-3	02B1	0.140	1.710	1.107	12.3	5.6	6.329	1.1837	79	2.5	21.1876	185.693
103	04-3	05B0	0.213	2.069	0.858	4.6	8.8	8.780	1.9096	96	-2.7	21.0177	189.862
104	04-3	05B0	0.339	1.828	1.222	2.8	30.0	8.352	1.6552	110	-4.9	21.4337	193.620
105	04-3	05B3	0.135	1.330	1.096	0.8	1.4	6.455	0.8058	97	3.8	20.8177	188.566
106	04-3	05B3	0.180	1.959	1.430	23.3	3.2	5.199	0.9600	88	3.8	20.8355	188.728
107	04-3	08B2	0.251	2.178	1.571	16.8	12.5	6.664	1.2311	93	3.8	21.1791	196.649
108	04-3	08B2	0.276	1.509	1.549	21.4	20.2	7.097	1.8325	116	7.6	21.0266	195.233
109	04-4	BASE	0.153	1.134	1.492	5.6	0.0	3.581	0.0000	55	6.6	22.1349	192.645
110	04-4	BASE	0.281	2.939	1.363	9.9	-2.9	3.431	0.0148	48	5.5	22.1195	192.511
111	04-4	02B0	0.206	1.206	2.049	19.2	2.9	4.573	0.4486	73	5.4	22.0506	191.080
112	04-4	02B0	0.120	1.755	1.855	25.6	7.5	3.783	0.0004	78	2.7	22.0017	190.656
113	04-4	02B1	0.160	1.107	1.719	33.5	1.1	3.840	0.9778	138	3.7	21.9969	192.786
114	04-4	02B1	0.136	0.783	1.336	15.6	1.4	4.195	0.6294	117	4.8	22.0260	193.042
115	04-4	05B0	0.275	1.159	2.016	16.9	-0.2	3.543	0.7292	123	7.2	21.7563	196.534
116	04-4	05B0	0.196	0.698	1.739	17.5	4.3	4.954	0.0011	185	10.8	21.4989	194.208
117	04-4	05B3	0.129	0.418	1.493	14.2	0.5	4.827	0.8821	193	13.5	21.4592	194.376
118	04-4	05B3	0.138	0.591	1.457	19.3	7.6	4.437	0.7947	194	15.8	21.6055	195.702
119	04-4	08B2	0.162	0.874	1.980	13.6	3.2	4.099	0.6194	77	12.4	21.5643	200.225
120	04-4	08B2	0.096	0.148	1.781	14.6	0.5	11.014	2.0957	97	15.9	21.4147	198.837

APPENDIX C

FUEL PROPERTIES

TABLE C-1

TEST FUEL PROPERTIES AS REPORTED BY THE SUPPLIER

VARIABLE	FUEL BASE	02B1	02B0	05B3	05B0	08B2
Methanol Content, Vol. %	0	3.33	3.50	8.67	9.70	13.40
	0	3.31	3.58	8.99	9.80	13.30
	-	3.30	3.53	-	-	-
Average	0	3.31	3.54	8.83	9.75	13.35
Iscbutanol Content, Vol. %	0	1.23	0.05	2.65	0	1.86
	0	1.20	0.05	2.67	0	1.74
	-	1.19	0.06	-	-	-
Average	0	1.21	0.05	2.66	0	1.80
RON	97.4	98.9	98.3	100.0	100.2	100.7
	97.4	99.0	98.2	100.0	-	100.5
Average	97.4	99.0	98.2	100.0	100.2	100.6
MON	86.6	86.9	86.8	86.6	86.8	86.9
	86.5	86.7	86.9	86.0	-	87.0
Average	86.6	86.8	86.8	86.3	86.8	87.0
(R+M)/2	92.0	92.9	92.6	93.3	93.4	93.8
	92.0	92.8	92.6	93.0	-	93.6
Average	92.0	92.8	92.6	93.2	93.4	93.7
API Gravity °API	59.4	54.6	54.4	54.8	54.5	54.1
	59.4	54.6	54.4	54.8	54.5	54.1
Average	59.4	54.6	54.4	54.8	54.5	54.1
Specific Gravity @15.6°C	0.741	0.760	0.761	0.760	0.761	0.762
Density, lb/Gal.	6.175	6.342	6.342	6.351	6.334	6.342
RVP, lb.	9.7	8.1	8.7	7.5	8.8	8.3
	9.7	8.0	8.7	7.7	8.6	8.4
Average	9.7	8.0	8.7	7.6	8.7	8.4
10% Slope	2.4	1.2	1.9	0.8	0.9	1.0
	2.4	1.0	1.0	1.0	0.9	1.0
Average	2.4	1.1	1.4	0.9	0.9	1.0
Distillation, IBP, °F	92	105	108	109	107	106
	88	108	104	110	107	109
Average	90	106	106	110	107	108
5%, °F	111	118	117	123	116	120
	110	121	115	122	117	[illegible]
Average	110	120	116	122	116	[illegible]
10%	124	124	118	128	121	125
	123	126	118	128	123	126
Average	124	125	118	128	122	[illegible]

TABLE C-1 (CONTINUED)

TEST FUEL PROPERTIES AS REPORTED BY THE SUPPLIER

VARIABLE	FUEL BASE	02B1	02B0	05B3	05B0	08B2
Distillation, 15%, °F	135	130	136	131	125	130
	134	131	125	132	126	130
Average	134	130	130	132	126	130
20%	147	146	156	135	128	134
	147	149	147	135	129	133
Average	147	148	152	135	128	134
30%	173	183	186	152	132	137
	174	186	183	154	134	138
Average	174	184	184	153	133	138
40%	201	205	212	201	185	149
	203	209	210	200	191	148
Average	202	207	211	200	188	148
50%	222	222	232	218	219	209
	223	226	230	220	222	207
Average	222	224	231	219	220	208
60%	237	237	247	232	234	233
	237	242	245	235	238	234
Average	237	240	246	234	236	234
70%	254	256	265	255	252	254
	254	260	265	256	257	255
Average	254	258	265	256	254	254
80%	278	285	292	287	279	282
	280	287	292	287	284	282
Average	279	286	292	287	282	282
90%	317	320	334	331	315	318
	319	324	337	333	322	321
Average	318	322	336	332	318	320
95%	354	350	372	368	341	352
	354	359	380	370	354	[illegible]
Average	354	355	376	369	348	[illegible]
FBP	403	405	427	402	403	[illegible]
	403	410	423	406	401	[illegible]
Average	403	408	425	404	402	[illegible]
Recovered, %	98.2	98.8	98.9	97.3	97.1	[illegible]
	98.2	98.7	97.4	97.3	96.8	[illegible]
Average	98.2	98.8	98.2	97.3	97.0	[illegible]

TABLE C-4. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB1 BASE FUEL (Continued)

VARIABLE		FOR BLEND (METHANOL (o/o) / ISOBUTANOL (o/o)) (0/0)	(3/0)	(3/1)*	(10/0)	(10/3.3)	(15/0)	(15/5)
DIST 60%	1ST:	240.00	233.00	234.00	233.00	219.00	225.00	207.00
	2ND:	238.00	228.00		233.00	215.00	230.00	215.00
	AVE:	239.00	230.50	234.00	233.00	217.00	227.50	211.00
DIST 70%	1ST:	260.00	254.00	251.00	254.00	242.00	248.00	233.00
	2ND:	256.00	250.00		255.00	240.00	250.00	235.00
	AVE:	258.00	252.00	251.00	254.50	241.00	249.00	234.00
DIST 80%	1ST:	285.00	281.00	276.00	281.00	270.00	273.00	265.00
	2ND:	285.00	275.00		285.00	265.00	280.00	270.00
	AVE:	285.00	278.00	276.00	283.00	267.50	276.50	267.50
DIST 90%	1ST:	329.00	323.00	317.00	325.00	310.00	305.00	308.00
	2ND:	321.00	315.00		330.00	300.00	310.00	312.00
	AVE:	325.00	319.00	317.00	327.50	305.00	307.50	310.00
DIST 95%	1ST:	365.00	371.00	350.00	372.00	352.00	345.00	350.00
	2ND:	355.00	360.00		380.00	350.00	354.00	355.00
	AVE:	360.00	365.50	350.00	376.00	351.00	349.50	352.50
DIST FBP	1ST:	408.00	410.00	400.00	404.00	383.00	388.00	392.00
	2ND:	403.00	415.00		410.00	400.00	404.00	402.00
	AVE:	405.50	412.50	400.00	407.00	391.50	396.00	397.00
RESIDUE %	1ST:	1.10	1.00	0.90	1.00	1.10	1.10	1.10
	2ND:	1.20	1.40		1.00	1.30	1.00	1.20
	AVE:	1.15	1.20	0.90	1.00	1.20	1.05	1.15
LOSS %	1ST:	0.70	1.60	1.00	1.60	1.10	1.10	1.10
	2ND:	0.60	1.60		1.40	1.10	1.40	1.20
	AVE:	0.65	1.60	1.00	1.50	1.10	1.25	1.15
V/L 5	1ST:	125.30	105.30	106.40	103.70	110.60	105.00	110.10
	2ND:	124.45	105.29		104.13	110.61	104.29	110.22
	AVE:	124.88	105.29	106.40	103.91	110.61	104.65	110.16
V/L 10	1ST:	128.60	107.10	108.70	105.20	112.10	106.30	111.60
	2ND:	128.83	107.13		105.88	112.44	106.67	112.03
	AVE:	128.71	107.12	108.70	105.54	112.27	106.48	111.82
V/L 15	1ST:	131.90	109.00	110.90	106.70	113.50	107.60	113.20
	2ND:	132.30	108.98		107.29	113.93	108.13	113.54
	AVE:	132.10	108.99	110.90	106.99	113.71	107.86	113.37
V/L 20	1ST:	135.20	110.80	113.20	108.20	115.00	109.00	114.70
	2ND:	135.53	110.83		108.62	115.33	109.36	114.97
	AVE:	135.37	110.81	113.20	108.41	115.16	109.18	114.83
V/L 25	1ST:	138.50	112.70	115.40	109.70	116.50	110.30	116.20
	2ND:	138.68	112.68		109.91	116.69	110.50	116.37
	AVE:	138.59	112.69	115.40	109.80	116.59	110.40	116.28
V/L 30	1ST:	141.80	114.50	117.70	111.20	118.00	111.60	117.70
	2ND:	141.79	114.52		111.18	118.04	111.60	117.75
	AVE:	141.79	114.51	117.70	111.19	118.02	111.60	117.72
V/L 35	1ST:	145.10	116.40	120.00	112.70	119.40	112.90	119.30
	2ND:	144.86	116.37		112.45	119.37	112.66	119.12
	AVE:	144.98	116.39	120.00	112.57	119.39	112.78	119.21
H2O -15°C	1ST:		0.05	0.11	*******	0.15	*******	0.25
	2ND:							
	AVE:		0.05	0.11	*******	0.15	*******	0.25
H2O 5°C	1ST:		0.07	0.14	0.06	0.26	0.02	0.41
	2ND:							
	AVE:		0.07	0.14	0.06	0.26	0.02	0.41
H2O 20°C	1ST:		0.08	0.16	0.11	0.34	0.11	0.53
	2ND:							
	AVE:		0.08	0.16	0.11	0.34	0.11	0.53

******Water separation occurred in original sample

TABLE C-4. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB1 BASE FUEL

VARIABLE		FOR BLEND (METHANOL (°/°) / ISOBUTANOL (°/°))						
		(0/0)	(3/0)	(3/1)*	(10/0)	(10/3.3)	(15/0)	(15/5)
ALCOHOL ÷	1ST:	0	3.00	4.00	10.00	13.30	15.00	20.00
	2ND:	0	3.00		10.00	13.30	15.00	20.00
	AVE:	0	3.00	4.00	10.00	13.30	15.00	20.00
RON	1ST:	96.70	97.40		97.50	99.10	100.30	100.70
	2ND:	96.70	97.80		97.50	99.00	100.10	97.30
	AVE:	96.70	97.60		97.50	99.05	100.20	99.00
MON	1ST:	86.60	86.80		86.80	86.80	86.80	
	2ND:	86.80	86.80		86.70	86.90	86.90	86.50
	AVE:	86.70	86.80		86.75	86.85	86.85	86.50
R+M/2	1ST:	91.65	92.10		92.15	92.95	93.55	100.70
	2ND:	91.75	92.30		92.10	92.95	93.50	91.90
	AVE:	91.70	92.20		92.12	92.95	93.52	96.30
°API	1ST:	59.70	59.80	58.90	58.50	58.30	58.00	57.00
	2ND:	59.50	60.00		58.70	58.40	58.20	57.20
	AVE:	59.60	59.90	58.90	58.60	58.35	58.10	57.10
158°F ÷	1ST:	28.80	30.00	28.50	33.80	44.60	45.70	48.20
	2ND:	29.70	31.70		33.40	43.70	45.00	47.80
	AVE:	29.25	30.85	28.50	33.60	44.15	45.35	48.00
ρ(LB/GAL)	1ST:	6.17	6.16	6.18	6.20	6.21	6.22	6.25
	2ND:	6.17	6.15		6.19	6.20	6.21	6.24
	AVE:	6.17	6.15	6.18	6.20	6.20	6.21	6.25
AROMATICS	1ST:	30.00	29.10	29.00	27.00	26.00	25.50	24.00
	2ND:	30.00	29.10		27.00	26.00	25.50	24.00
	AVE:	30.00	29.10	29.00	27.00	26.00	25.50	24.00
RVP	1ST:	9.60	12.10	11.20	12.40	12.40	12.40	11.60
	2ND:	9.70	11.90		12.50	12.30	12.40	11.80
	AVE:	9.65	12.00	11.20	12.45	12.35	12.40	11.70
10÷ SLOPE	1ST:	2.40	1.20	1.40	1.10	1.10	0.60	1.00
	2ND:	2.40	1.50		1.00	1.00	0.60	1.00
	AVE:	2.40	1.35	1.40	1.05	1.05	0.60	1.00
DIST IBP	1ST:	89.00	97.00	8.50	99.00	89.00	95.00	97.00
	2ND:	89.00	95.00		102.00	85.00	95.00	100.00
	AVE:	89.00	96.00	8.50	100.50	87.00	95.00	98.50
DIST 5÷	1ST:	103.00	103.00	99.00	105.00	96.00	111.00	110.00
	2ND:	104.00	100.00		107.00	94.00	112.00	112.00
	AVE:	103.50	101.50	99.00	106.00	95.00	111.50	111.00
DIST 10÷	1ST:	115.00	109.00	106.00	111.00	102.00	115.00	115.00
	2ND:	117.00	107.00		115.00	100.00	116.00	118.00
	AVE:	116.00	108.00	106.00	113.00	101.00	115.50	116.50
DIST 15÷	1ST:	126.00	115.00	113.00	116.00	107.00	117.00	120.00
	2ND:	128.00	115.00		117.00	104.00	118.00	123.00
	AVE:	127.00	115.00	113.00	116.50	105.50	117.50	121.50
DIST 20÷	1ST:	139.00	125.00	125.00	119.00	119.00	122.00	125.00
	2ND:	137.00	119.00		120.00	114.00	124.00	128.00
	AVE:	138.00	122.00	125.00	119.50	116.50	123.00	126.50
DIST 30÷	1ST:	163.00	157.00	164.00	143.00	130.00	126.00	132.00
	2ND:	168.00	153.00		144.00	125.00	128.00	135.00
	AVE:	165.50	155.00	164.00	143.50	127.50	127.00	133.50
DIST 40÷	1ST:	194.00	189.00	194.00	184.00	141.00	135.00	142.00
	2ND:	192.00	185.00		184.00	141.00	140.00	150.00
	AVE:	193.00	187.00	194.00	184.00	141.00	137.50	146.00
DIST 50÷	1ST:	222.00	214.00	218.00	213.00	193.00	181.00	163.00
	2ND:	218.00	210.00		215.00	190.00	186.00	165.00
	AVE:	220.00	212.00	218.00	214.00	191.50	183.50	164.00

*Water separation occurred in original sample

TABLE C-3. INSPECTION DATA OF TRIAL BLENDS OF METHANOL BASE FUEL (CONTINUED)

VARIABLE		MB1 BASE	MB2 BASE	MB3 BASE	MB4 BASE
DIST 30÷	1ST:	163.00	212.00	206.00	192.00
	2ND:	168.00	208.00	205.00	193.00
	AVE:	165.50	210.00	205.50	192.50
DIST 40÷	1ST:	194.00	231.00	223.00	215.00
	2ND:	192.00	227.00	222.00	217.00
	AVE:	193.00	229.00	222.50	216.00
DIST 50÷	1ST:	222.00	240.00	235.00	232.00
	2ND:	218.00	240.00	238.00	234.00
	AVE:	220.00	240.00	236.50	233.00
DIST 60÷	1ST:	240.00	254.00	248.00	247.00
	2ND:	238.00	252.00	252.00	249.00
	AVE:	239.00	253.00	250.00	248.00
DIST 70÷	1ST:	260.00	272.00	264.00	263.00
	2ND:	256.00	269.00	268.00	263.00
	AVE:	258.00	270.50	266.00	263.00
DIST 80÷	1ST:	285.00	293.00	290.00	286.00
	2ND:	285.00	290.00	289.00	288.00
	AVE:	285.00	291.50	289.50	287.00
DIST 90÷	1ST:	329.00	331.00	326.00	319.00
	2ND:	321.00	324.00	326.00	320.00
	AVE:	325.00	327.50	326.00	319.50
DIST 95÷	1ST:	365.00	380.00	362.00	357.00
	2ND:	355.00	367.00	373.00	359.00
	AVE:	360.00	373.50	367.50	358.00
DIST FBP	1ST:	408.00	428.00	411.00	404.00
	2ND:	403.00	428.00	408.00	409.00
	AVE:	405.50	428.00	409.50	406.50
RESIDUE ÷	1ST:	1.10	0.90	1.30	1.00
	2ND:	1.20	0.90	1.10	0.90
	AVE:	1.15	0.90	1.20	0.95
LOSS ÷	1ST:	0.70	0.60	0.60	0.90
	2ND:	0.60	0.60	0.60	0.90
	AVE:	0.65	0.60	0.60	0.90
V/L 5	1ST:	125.30	166.00	172.80	144.80
	2ND:	124.45	165.41	172.78	143.30
	AVE:	124.88	165.70	172.79	144.05
V/L 10	1ST:	128.60	169.70	176.10	148.60
	2ND:	128.83	171.13	176.96	149.03
	AVE:	128.71	170.42	176.53	148.81
V/L 15	1ST:	131.90	173.40	179.30	152.40
	2ND:	132.30	174.99	180.26	153.15
	AVE:	132.10	174.19	179.78	152.77
V/L 20	1ST:	135.20	177.10	182.60	156.20
	2ND:	135.53	178.37	183.33	156.86
	AVE:	135.37	177.74	182.96	156.53
V/L 25	1ST:	138.50	180.90	185.80	160.10
	2ND:	138.68	181.57	186.31	160.41
	AVE:	138.59	181.24	186.05	160.25
V/L 30	1ST:	141.80	184.60	189.00	163.90
	2ND:	141.79	184.68	189.24	163.88
	AVE:	141.79	184.64	189.12	163.89
V/L 35	1ST:	145.10	188.30	192.30	167.70
	2ND:	144.86	187.73	192.15	167.30
	AVE:	144.98	188.02	192.23	167.50

TABLE C-3. INSPECTION DATA OF TRIAL BLENDS OF METHANOL BASE FUEL

VARIABLE		MB1 BASE	MB2 BASE	MB3 BASE	MB4 BASE
ALCOHOL %	1ST:	0	0	0	0
	2ND:	0	0	0	0
	AVE:	0	0	0	0
RON	1ST:	96.70	97.40	98.90	98.40
	2ND:	96.70	97.60	98.70	98.50
	AVE:	96.70	97.50	98.80	98.45
MON	1ST:	86.60	86.80	86.40	87.00
	2ND:	86.80	86.80	86.10	87.00
	AVE:	86.70	86.80	86.25	87.00
R+M/2	1ST:	91.65	92.10	92.65	92.70
	2ND:	91.75	92.20	92.40	92.75
	AVE:	91.70	92.15	92.52	92.72
°API	1ST:	59.70	53.60	53.00	56.00
	2ND:	59.50	53.40	53.10	56.10
	AVE:	59.60	53.50	53.05	56.05
158°F %	1ST:	28.80	9.50	6.80	16.90
	2ND:	29.70	8.00	8.90	17.00
	AVE:	29.25	8.75	7.85	16.95
ρ(LB/GAL)	1ST:	6.17	6.36	6.39	6.28
	2ND:	6.17	6.37	6.38	6.28
	AVE:	6.17	6.37	6.38	6.28
AROMATICS	1ST:	30.00	36.00	36.00	33.00
	2ND:	30.00	36.00	36.00	33.00
	AVE:	30.00	36.00	36.00	33.00
RVP	1ST:	9.60	5.10	4.70	7.30
	2ND:	9.70	5.30	4.90	7.40
	AVE:	9.65	5.20	4.80	7.35
10% SLOPE	1ST:	2.40	3.00	3.00	3.10
	2ND:	2.40	3.10	3.20	3.20
	AVE:	2.40	3.05	3.10	3.15
DIST IBP	1ST:	89.00	113.00	122.00	99.00
	2ND:	89.00	113.00	120.00	100.00
	AVE:	89.00	113.00	121.00	99.50
DIST 5%	1ST:	103.00	145.00	151.00	123.00
	2ND:	104.00	144.00	144.00	124.00
	AVE:	103.50	144.50	147.50	123.50
DIST 10%	1ST:	115.00	165.00	168.00	140.00
	2ND:	117.00	162.00	162.00	141.00
	AVE:	116.00	163.50	165.00	140.50
DIST 15%	1ST:	126.00	177.00	181.00	154.00
	2ND:	128.00	175.00	176.00	156.00
	AVE:	127.00	176.00	178.50	155.00
DIST 20%	1ST:	139.00	192.00	190.00	166.00
	2ND:	137.00	188.00	187.00	168.00
	AVE:	138.00	190.00	188.50	167.00

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

RAW V/L DATA

Fuel Identification	Temp[a] (°F)	Measured V/L[b] Run 1	Run 2	Linear Regression Line[c] Intercept	Slope	r
MB2 (0/0)	154.4	1.67	1.11	Analyzed Graphically[d]		
	159.8	5.00	4.44			
	165.2	12.22	12.22			
	170.6	22.22	21.67			
	178.7	35.00	35.00			
MB2 (14/2)	120.2	2.22	2.22	Analyzed Graphically[d]		
	122.0	5.55	5.55			
	123.8	12.77	12.77			
	127.4	33.33	33.33			
MB2 (3.3/1.1)	123.8	3.89	3.89	121.93	0.4568	0.9991
	125.6	7.78	7.78			
	127.4	11.67	11.67			
	129.2	16.67	16.67			
	132.8	24.44	24.44			
	136.4	31.67	31.67			
	138.2	35.00	35.00			
MB2 (10/0)	120.2	5.55	5.55	119.52	0.1751	0.9918
	122.0	12.77	12.77			
	123.8	22.22	23.88			
	125.6	35.55	36.11			
MB2 (3.8/0)	120.2	1.67	1.67	119.48	0.3987	0.9993
	123.8	10.56	10.56			
	127.4	20.56	20.56			
	132.8	33.89	33.89			
	134.6	37.22	37.22			

a - Test temperature.

b - Measured V/L.

c - Best fit of data to equation: Temp = Intercept + (Slope x V/L).

d - Because of curvature, interpolated values were determined graphically.

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

RAW WATER TOLERANCE DATA

Fuel Identification	Added Water[a] (Vol %)	Temp[b] (°C)	Linear Regression Line[c] Intercept	Slope	r
MB2 (14/2) : 08B2	0.000	-32.6	-31.70	196.4	0.9994
	0.050	-21.4			
	0.100	-11.2			
	0.200	7.5			
	0.250	17.0			
MB2 (3.3/1.1) : 02B1	0.050	- 9.8	-47.81	780.4	0.9914
	0.0625	1.3			
	0.075	12.2			
	0.075	11.8			
	0.086	17.4			
MB2 (10/0) : 05B0	0.000	-16.1	-14.52	320.0	0.9949
	0.025	- 5.2			
	0.050	2.5			
	0.075	9.8			
	0.100	16.4			
MB2 (3.8/0) : 02B0	0.000	-31.5	-28.90	997.9	0.9932
	0.015	-12.3			
	0.025	- 3.2			
	0.025	- 2.6			
	0.035	7.4			
	0.050	18.5			

a - Amount of water added to fuel.

b - Temperature at which treated fuel exhibited phase separation.

c - Best fit of data to equation: Temp = Intercept + (Slope x Added Water).

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

02B0	Run 1	Run 2	Run 3	Run 4	Average
Volume % Methanol	3.70	3.64	3.65	3.56	3.64
Volume % Isobutanol	--------	--------	-----	-----	-------
Volume % Water	0.024	0.032	0.022	-----	0.026
API Gravity	54.6	54.6	-----	-----	54.6
Reid Vapor Pressure (psi)	9.2	9.1	-----	-----	9.15
D 86 Distillation					
IBP °F	107	106	-----	-----	106.5
5%	118	116	-----	-----	117.0
10%	120	120	-----	-----	120.0
15%	127	125	-----	-----	126.0
20%	147	145	-----	-----	146.0
30%	186	186	-----	-----	186.0
40%	212	211	-----	-----	211.5
50%	230	231	-----	-----	230.5
60%	246	247	-----	-----	246.5
70%	265	265	-----	-----	265.0
80%	294	293	-----	-----	293.5
90%	333	334	-----	-----	333.5
95%	369	367	-----	-----	368.0
EP	417	417	-----	-----	417.0
Recovery	97.0	96.9			
Residue	1.2	1.2			
Loss	1.8	1.9			

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

05B0	Run 1	Run 2	Run 3	Run 4	Average
Volume % Methanol	9.82	9.76	9.80	9.83	9.80
Volume % Isobutanol	-------	-------	-----	-----	-------
Volume % Water	0.029	0.029	0.032	-----	0.030
API Gravity	54.4	54.4	-----	-----	54.4
Reid Vapor Pressure (psi)	9.3	9.2	-----	-----	9.25
D 86 Distillation					
IBP °F	107	105	-----	-----	106.0
5%	117	116	-----	-----	116.5
10%	121	120	-----	-----	120.5
15%	124	123	-----	-----	123.5
20%	127	126	-----	-----	126.5
30%	132	132	-----	-----	132.0
40%	196	194	-----	-----	195.0
50%	224	223	-----	-----	223.5
60%	239	239	-----	-----	239.0
70%	257	257	-----	-----	257.0
80%	285	285	-----	-----	285.0
90%	325	324	-----	-----	324.5
95%	360	359	-----	-----	359.5
EP	410	410	-----	-----	410.0
Recovery	98.0	98.0			
Residue	1.0	1.0			
Loss	1.0	1.0			

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

02B1	Run 1	Run 2	Run 3	Run 4	Average
Volume % Methanol	3.13	3.12	3.15	3.15	3.14
Volume % Isobutanol	1.08	1.08	1.08	1.09	1.08
Volume % Water	0.031	0.031	0.031	-----	0.031
API Gravity	54.6	54.6	-----	-----	54.6
Reid Vapor Pressure (psi)	8.5	8.4	-----	-----	8.45
D 86 Distillation					
IBP °F	104	105	-----	-----	104.5
5%	116	117	-----	-----	116.5
10%	121	122	-----	-----	121.5
15%	130	132	-----	-----	131.0
20%	152	152	-----	-----	152.0
30%	186	185	-----	-----	185.5
40%	208	208	-----	-----	208.0
50%	227	227	-----	-----	227.0
60%	244	244	-----	-----	244.0
70%	264	263	-----	-----	263.5
80%	291	293	-----	-----	292.0
90%	330	333	-----	-----	331.5
95%	367	367	-----	-----	367.0
EP	413	413	-----	-----	413.0
Recovery	97.4	97.3			
Residue	1.1	1.2			
Loss	1.5	1.5			

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

08B2	Run 1	Run 2	Run 3	Run 4	Average
Volume % Methanol	14.04	13.92	13.89	13.83	13.92
Volume % Isobutanol	2.02	2.02	2.00	2.04	2.02
Volume % Water	0.040	0.035	0.038	------	0.038
API Gravity	53.6	53.6	------	------	53.6
Reid Vapor Pressure (psi)	8.75	8.75	------	------	8.75
D 86 Distillation					
IBP °F	106	105	------	------	105.5
5%	116	116	------	------	116.0
10%	123	123	------	------	123.0
15%	127	127	------	------	127.0
20%	130	130	------	------	130.0
30%	135	135	------	------	135.0
40%	144	144	------	------	144.0
50%	207	209	------	------	208.0
60%	232	234	------	------	233.0
70%	253	252	------	------	252.5
80%	284	285	------	------	284.5
90%	325	326	------	------	325.5
95%	360	359	------	------	359.5
EP	405	405	------	------	405.0
Recovery	97.0	97.0			
Residue	0.9	0.9			
Loss	2.1	2.1			

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL (CONTINUED)

MB2 BASE GASOLINE	Run 1	Run 2	Average
Volume % Methanol	-----	------	------
Volume % Isobutanol	-----	------	------
Volume % Water	-----	------	------
API Gravity	53.9	53.9	53.9
Reid Vapor Pressure (psi)	5.0	4.95	4.98
D 86 Distillation			
IBP °F	109	109	109.0
5%	141	139	140.0
10%	157	155	156.0
15%	169	167	168.0
20%	180	179	179.5
30%	205	205	205.0
40%	225	226	225.5
50%	240	241	240.5
60%	254	256	255.0
70%	273	273	273.0
80%	299	299	299.0
90%	335	335	335.0
95%	363	369	366.0
EP	413	415	414.0
Recovery	98.1	97.7	
Residue	1.0	0.9	
Loss	0.9	1.4	

TABLE C-2. INSPECTION DATA ON HAND BLENDS FROM MB2 BASE FUEL

	MB2	08B2	02B1	05B0	02B0
Volume % Methanol	------	13.92	3.14	9.80	3.64
Volume % Isobutanol	------	2.02	1.08	------	------
Volume % Water	------	0.038	0.031	0.030	0.026
API Gravity	53.9	53.6	54.6	54.4	54.6
Reid Vapor Pres. (psi)	4.98	8.75	8.45	9.25	9.15
D 86 Distillation					
IBP °F	109.0	105.5	104.5	106.0	106.5
5%	140.0	116.0	116.5	116.5	117.0
10%	156.0	123.0	121.5	120.5	120.0
15%	168.0	127.0	131.0	123.5	126.0
20%	179.5	130.0	152.0	126.5	146.0
30%	205.0	135.0	185.5	132.0	186.0
40%	225.5	144.0	208.0	195.0	211.5
50%	240.5	208.0	227.0	223.5	230.5
60%	255.0	233.0	244.0	239.0	246.5
70%	273.0	252.5	263.5	257.0	265.0
80%	299.0	284.5	292.0	285.0	293.5
90%	335.0	325.5	331.5	324.5	333.5
95%	366.0	359.5	367.0	359.5	368.0
EP	414.0	405.0	413.0	410.0	417.0
Water Tolerance (Vol %) @					
20C	------	0.301	0.118	0.138	0.075
5C	------	0.224	0.099	0.091	0.060
-15C	------	0.122	0.073	0.028	0.040
Temperature (°F) At Which V/L =					
5	159.9	121.6	124.2	120.4	121.5
10	163.7	123.1	126.5	121.3	123.5
15	166.8	124.3	128.8	122.1	125.4
20	169.8	125.3	131.1	123.0	127.4
25	172.8	126.2	133.3	123.9	129.4
30	175.8	127.0	135.6	124.8	131.4
35	178.8	127.8	137.9	125.6	133.4
40	181.8	-------	140.2	126.5	135.4

TABLE C-1 (CONTINUED)

TEST FUEL PROPERTIES AS REPORTED L THE SUPPLIER

VARIABLE	FUEL BASE	02B1	02B0	05B3	05B0	08B2
Net Heat of Combustion						
Btu/lb	18,594	17,927	18,276	17,348	17,475	16,972
	18,580	18,010	18,331	17,329	17,510	16,994
Average	18,587	17,968	18,304	17,338	17,492	16,983
Elemental Analysis						
C wt. %	86.46	84.88	86.47	81.59	81.87	80.13
	-	84.68	86.28	82.00	81.94	80.23
Average	86.46	84.78	86.38	81.80	81.90	80.18
H wt. %	13.10	12.79	12.48	12.99	13.04	12.79
	13.08	12.85	12.64	13.38	13.00	12.76
Average	13.09	12.82	12.56	13.18	13.02	12.78
O wt. %	0.44	2.33	1.05	5.42	5.09	7.08
(by difference)	-	2.47	1,08	4.62	5.06	7.01
Average	0.44	2.40	1.06	5.02	5.08	7.04
GC Analysis, wt. %						
Butanes	6.20	0.48	0.28	0.56	0.53	0.43
	-	0.61	-	-	0.59	-
Average	6.20	0.55	0.28	0.56	0.56	0.43
Pentanes	15.16	10.82	12.50	7.60	10.85	9.70
	-	11.85	-	-	11,85	-
Average	15.16	11.34	12.50	7.60	11.35	9.70
Calculate Equivalent Base Fuel C_4, C_5 Composition Wt. %						
Butanes	6.20	0.50	0.29	0.64	0.59	0.52
	-	0.64	-	-	0.66	-
Average	6.20	0.57	0.29	0.64	0.62	0.52
Pentanes	15.16	11.35	13.03	18.67	12.13	11.67
	-	12.43	-	-	13.24	-
Average	15.16	11.89	13.03	18.67	12.68	11.67

TABLE C-1 (CONTINUED)

TEST FUEL PROPERTIES AS REPORTED BY THE SUPPLIER

VARIABLE	FUEL					
	BASE	02B1	02B0	05B3	05B0	08B2
Residue, %	0.9	1.0	1.0	1.0	0.9	1.2
	0.9	1.1	0.9	1.0	0.9	1.0
Average	0.9	1.0	1.0	1.0	0.9	1.1
Loss, %	0.9	0.2	0.1	1.7	2.0	1.3
	0.9	0.2	1.7	1.7	2.3	1.1
Average	0.9	0.2	0.9	1.7	2.2	1.2
Vol. % Distillated at 158° F	24.2	23.2	20.7	31.2	34.9	41.5
	24.1	22.4	23.1	30.9	34.2	41.7
Average	24.2	22.8	21.9	31.0	34.6	41.6
Temperature to Obtain						
V/L = 5, $^{\circ}$F	124.4	124.4	122.6	127.0	120.2	121.2
	124.0	124.5	122.5	126.8	120.2	121.0
Average	124.2	124.4	122.6	126.9	120.2	121.1
V/L = 10	128.0	126.4	124.7	128.4	121.8	122.4
	127.6	126.4	124.7	128.6	121.8	122.2
Average	127.8	126.4	124.7	128.5	121.8	122.3
V/L = 15	131.5	128.4	126.5	129.8	123.0	123.5
	131.2	128.3	126.4	129.9	123.0	123.3
Average	131.4	128.4	126.4	129.8	123.0	123.4
V/L = 20	135.0	130.3	128.4	130.8	123.8	124.6
	134.8	130.2	128.4	131.0	123.8	124.4
Average	134.9	130.2	128.4	130.9	123.8	124.5
V/L = 25	138.6	132.3	131.1	131.8	124.5	125.8
	138.4	132.2	131.0	132.0	124.5	125.6
Average	138.5	132.2	131.0	131.9	124.5	125.7
V/L = 30	142.2	134.3	134.0	133.0	125.2	126.9
	142.0	134.1	134.2	132.9	125.2	126.7
Average	142.1	134.2	134.1	132.9	125.2	126.8
V/L = 35	145.8	136.3	137.9	133.8	125.9	128.0
	145.6	136.0	137.9	134.0	125.9	127.8
Average	145.7	136.2	137.9	133.9	125.9	127.9
Water Tolerance, Vol. % at:						
-15°C	-	0.108	0.029	0.188	0.045	0.165
5°C	-	0.137	0.054	0.253	0.102	0.274
20°C	-	0.159	0.073	0.320	0.145	0.355

TABLE C-5. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB2a BASE FUEL (40% PENTANE REMOVAL)

E2 + BASE BLEND 2

VARIABLE		(0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)	(15/5)
		FOR BLEND (METHANOL (%) / ISOBUTANOL (%))						
ALCOHOL %	1ST:	0	3.00	4.00	10.00	13.30	15.00	20.00
	2ND:	0	3.00	4.00	10.00	13.30	15.00	20.00
	AVE:	0	3.00	4.00	10.00	13.30	15.00	20.00
RON	1ST:	97.40	98.40	98.50	99.20	100.40	100.80	100.90
	2ND:	97.60	98.20	98.40	99.70	100.40	101.00	101.60
	AVE:	97.50	98.30	98.45	99.45	100.40	100.90	101.25
MON	1ST:	86.80	86.70	86.90	87.10	87.30	87.50	87.50
	2ND:	86.80	86.80	87.00	87.10	87.40	87.60	87.60
	AVE:	86.80	86.75	86.95	87.10	87.35	87.55	87.55
R+M/2	1ST:	92.10	92.55	92.70	93.15	93.85	94.15	94.20
	2ND:	92.20	92.50	92.70	93.40	93.90	94.30	94.60
	AVE:	92.15	92.52	92.70	93.27	93.87	94.22	94.40
°API	1ST:	53.60	53.40	53.20	53.30	53.10	52.90	52.70
	2ND:	53.40	53.60	53.60	53.20	52.80	53.10	52.50
	AVE:	53.50	53.50	53.40	53.25	52.95	53.00	52.60
158°F %	1ST:	9.50	16.00	14.40	28.40	30.60	39.50	36.50
	2ND:	8.00	15.90	14.50	28.90	29.60	40.00	39.40
	AVE:	8.75	15.95	14.45	28.65	30.10	39.75	37.95
ρ(LB/GAL)	1ST:	6.36	6.37	6.38	6.38	6.38	6.39	6.40
	2ND:	6.37	6.36	6.36	6.38	6.39	6.38	6.40
	AVE:	6.37	6.37	6.37	6.38	6.39	6.38	6.40
AROMATICS	1ST:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
	2ND:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
	AVE:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
RVP	1ST:	5.10	7.80	6.90	7.70	7.80	7.70	7.50
	2ND:	5.30	7.90	7.10	7.80	7.60	7.80	
	AVE:	5.20	7.85	7.00	7.75	7.70	7.75	7.50
10% SLOPE	1ST:	3.00	3.00	4.00	1.20	1.20	1.00	1.10
	2ND:	3.10	3.20	4.20	1.20	1.30	0.70	0.80
	AVE:	3.05	3.10	4.10	1.20	1.25	0.85	0.95
DIST IBP	1ST:	113.00	109.00	107.00	115.00	113.00	113.00	115.00
	2ND:	113.00	110.00	104.00	115.00	116.00	108.00	112.00
	AVE:	113.00	109.50	105.50	115.00	114.50	110.50	113.50
DIST 5%	1ST:	145.00	120.00	121.00	123.00	124.00	125.00	124.00
	2ND:	144.00	120.00	118.00	125.00	128.00	123.00	118.00
	AVE:	144.50	120.00	119.50	124.00	126.00	124.00	121.00
DIST 10%	1ST:	165.00	130.00	136.00	130.00	131.00	131.00	130.00
	2ND:	162.00	126.00	134.00	132.00	137.00	127.00	123.00
	AVE:	163.50	128.00	135.00	131.00	134.00	129.00	126.50
DIST 15%	1ST:	177.00	150.00	161.00	135.00	136.00	135.00	135.00
	2ND:	175.00	152.00	160.00	137.00	141.00	130.00	125.00
	AVE:	176.00	151.00	160.50	136.00	138.50	132.50	130.00
DIST 20%	1ST:	192.00	178.00	184.00	137.00	142.00	138.00	139.00
	2ND:	188.00	181.00	180.00	138.00	143.00	132.00	127.00
	AVE:	190.00	179.50	182.00	137.50	142.50	135.00	133.00
DIST 30%	1ST:	212.00	205.00	210.00	164.00	157.00	142.00	149.00
	2ND:	208.00	203.00	205.00	164.00	160.00	140.00	136.00
	AVE:	210.00	204.00	207.50	164.00	158.50	141.00	142.50
DIST 40%	1ST:	231.00	220.00	227.00	216.00	202.00	160.00	165.00
	2ND:	227.00	218.00	222.00	215.00	208.00	158.00	160.00
	AVE:	229.00	219.00	224.50	215.50	205.00	159.00	162.50
DIST 50%	1ST:	240.00	235.00	241.00	232.00	223.00	226.00	210.00
	2ND:	240.00	231.00	238.00	230.00	229.00	228.00	207.00
	AVE:	240.00	233.00	239.50	231.00	226.00	227.00	208.50

TABLE C-5. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB2a BASE FUEL (40% PENTANE REMOVAL) - (Continued)

VARIABLE		FOR BLEND (METHANOL (%) / ISOBUTANOL (%)) (0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)	(15/5)
DIST 60%	1ST:	254.00	250.00	255.00	246.00	241.00	242.00	232.00
	2ND:	252.00	249.00	251.00	240.00	244.00	246.00	226.00
	AVE:	253.00	249.50	253.00	243.00	242.50	244.00	229.00
DIST 70%	1ST:	272.00	267.00	272.00	264.00	261.00	261.00	253.00
	2ND:	269.00	263.00	267.00	261.00	270.00	265.00	248.00
	AVE:	270.50	265.00	269.50	262.50	265.50	263.00	250.50
DIST 80%	1ST:	293.00	290.00	297.00	286.00	285.00	282.00	279.00
	2ND:	290.00	296.00	290.00	281.00	292.00	292.00	280.00
	AVE:	291.50	293.00	293.50	283.50	288.50	287.00	279.50
DIST 90%	1ST:	331.00	326.00	340.00	323.00	319.00	317.00	316.00
	2ND:	324.00	330.00	335.00	322.00	325.00	327.00	321.00
	AVE:	327.50	328.00	337.50	322.50	322.00	322.00	318.50
DIST 95%	1ST:	380.00	365.00	392.00	365.00	362.00	360.00	355.00
	2ND:	367.00	373.00	388.00	365.00	383.00	377.00	366.00
	AVE:	373.50	369.00	390.00	365.00	372.50	368.50	360.50
DIST FBP	1ST:	428.00	418.00	428.00	414.00	416.00	414.00	406.00
	2ND:	428.00	423.00	417.00	412.00	420.00	412.00	413.00
	AVE:	428.00	420.50	422.50	413.00	418.00	413.00	409.50
RESIDUE %	1ST:	0.90	1.40	1.20	1.20	1.20	1.20	1.20
	2ND:	0.90	1.40	1.10	1.20	1.10	1.10	1.00
	AVE:	0.90	1.40	1.15	1.20	1.15	1.15	1.10
LOSS %	1ST:	0.60	0.50	1.20	0.60	0.60	0.50	0.50
	2ND:	0.60	0.70	1.40	0.60	0.50	0.70	0.50
	AVE:	0.60	0.60	1.30	0.60	0.55	0.60	0.50
V/L 5	1ST:	166.00	127.55	129.70	125.50	128.50	124.50	128.00
	2ND:	165.41	127.63	129.71	125.53	128.79	124.45	128.04
	AVE:	165.70	127.59	129.70	125.51	128.65	124.48	128.02
V/L 10	1ST:	169.70	129.25	132.90	126.50	130.10	125.50	129.10
	2ND:	171.13	130.63	132.90	126.49	130.24	126.05	129.90
	AVE:	170.42	129.94	132.90	126.50	130.17	125.77	129.50
V/L 15	1ST:	173.40	132.25	136.10	127.30	131.10	126.50	130.20
	2ND:	174.99	133.64	136.09	127.29	131.27	127.06	131.00
	AVE:	174.19	132.94	136.10	127.29	131.19	126.78	130.60
V/L 20	1ST:	177.10	135.85	139.30	128.00	132.10	127.50	131.30
	2ND:	178.37	136.64	139.29	128.04	132.20	127.93	131.92
	AVE:	177.74	136.25	139.29	128.02	132.15	127.71	131.61
V/L 25	1ST:	180.90	139.40	142.50	128.80	133.00	128.60	132.40
	2ND:	181.57	139.65	142.48	128.78	133.09	128.74	132.76
	AVE:	181.24	139.53	142.49	128.79	133.04	128.67	132.58
V/L 30	1ST:	184.60	143.05	145.70	129.50	134.00	129.60	133.40
	2ND:	184.68	142.66	145.67	129.51	133.96	129.52	133.56
	AVE:	184.64	142.85	145.68	129.51	133.98	129.56	133.48
V/L 35	1ST:	188.30	146.60	148.90	130.30	134.90	130.60	134.50
	2ND:	187.73	145.66	148.86	130.24	134.81	130.28	134.34
	AVE:	188.02	146.13	148.88	130.27	134.85	130.44	134.42
H2O -15°C	1ST:		0.02	0.06	0.01	0.17	*******	0.30
	2ND:							
	AVE:		0.02	0.06	0.01	0.17	*******	0.30
H2O 5°C	1ST:		0.04	0.08	0.07	0.25	0.09	0.46
	2ND:							
	AVE:		0.04	0.08	0.07	0.25	0.09	0.46
H2O 20°C	1ST:		0.06	0.10	0.12	0.32	0.18	0.57
	2ND:							
	AVE:		0.06	0.10	0.12	0.32	0.18	0.57

*******Water separation occurred in original sample

TABLE C-6. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB3 BASE FUEL

MB3 - BASE BLEND 3

FOR BLEND (METHANOL (%) / ISOBUTANOL (%))

VARIABLE		(0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)	(15/5)
ALCOHOL %	1ST:	0	3.00	4.00	10.00	13.30	15.00	20.00
	2ND:	0	3.00	4.00	10.00	13.30	15.00	20.00
	AVE:	0	3.00	4.00	10.00	13.30	15.00	20.00
RON	1ST:	98.90	98.60	98.60	99.60	99.90	100.40	100.70
	2ND:	98.70	98.80	98.80	99.40	99.70	100.30	100.90
	AVE:	98.80	98.70	98.70	99.50	99.80	100.35	100.80
MON	1ST:	86.40	86.70	86.90	87.20	87.10	87.50	88.10
	2ND:	86.10	86.60	86.80	87.10	87.40	87.70	88.30
	AVE:	86.25	86.65	86.85	87.15	87.25	87.60	88.20
R+M/2	1ST:	92.65	92.65	92.75	93.40	93.50	93.95	94.40
	2ND:	92.40	92.70	92.80	93.25	93.55	94.00	94.60
	AVE:	92.52	92.67	92.77	93.32	93.52	93.97	94.50
°API	1ST:	53.00	53.40	53.30	53.00	52.90	52.50	52.00
	2ND:	53.10	53.20	53.10	52.80	52.80	52.40	52.10
	AVE:	53.05	53.30	53.20	52.90	52.85	52.45	52.05
158°F %	1ST:	6.80	15.00	15.50	27.00	28.60	35.00	37.80
	2ND:	8.90	17.60	16.10	26.20	31.80	35.90	43.30
	AVE:	7.85	16.30	15.80	26.60	30.20	35.45	40.55
ρ(LB/GAL)	1ST:	6.39	6.37	6.38	6.39	6.39	6.40	6.42
	2ND:	6.38	6.38	6.38	6.39	6.39	6.41	6.42
	AVE:	6.38	6.37	6.38	6.39	6.39	6.40	6.42
AROMATICS	1ST:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
	2ND:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
	AVE:	36.00	34.90	34.60	32.40	31.20	30.60	28.80
RVP	1ST:	4.70	6.90	7.20	7.10	6.90	7.30	7.20
	2ND:	4.90	6.90	7.30	7.40	7.00		7.40
	AVE:	4.80	6.90	7.25	7.25	6.95	7.30	7.30
10% SLOPE	1ST:	3.00	3.40	2.90	0.40	0.80	0.80	0.60
	2ND:	3.20	2.10	2.70	0.60	0.60	1.00	0.80
	AVE:	3.10	2.75	2.80	0.50	0.70	0.90	0.70
DIST IBP	1ST:	122.00	119.00	117.00	119.00	121.00	119.00	119.00
	2ND:	120.00	115.00	109.00	123.00	115.00	121.00	117.00
	AVE:	121.00	117.00	113.00	121.00	118.00	120.00	118.00
DIST 5%	1ST:	151.00	126.00	126.00	129.00	129.00	126.00	131.00
	2ND:	144.00	121.00	124.00	133.00	122.00	127.00	127.00
	AVE:	147.50	123.50	125.00	131.00	125.50	126.50	129.00
DIST 10%	1ST:	168.00	134.00	130.00	131.00	133.00	130.00	133.00
	2ND:	162.00	129.00	128.00	136.00	126.00	133.00	132.00
	AVE:	165.00	131.50	129.00	133.50	129.50	131.50	132.50
DIST 15%	1ST:	181.00	160.00	155.00	133.00	137.00	134.00	137.00
	2ND:	176.00	142.00	151.00	139.00	128.00	137.00	135.00
	AVE:	178.50	151.00	153.00	136.00	132.50	135.50	136.00
DIST 20%	1ST:	190.00	184.00	180.00	137.00	141.00	136.00	141.00
	2ND:	187.00	176.00	175.00	142.00	130.00	141.00	137.00
	AVE:	188.50	180.00	177.50	139.50	135.50	138.50	139.00
DIST 30%	1ST:	206.00	207.00	205.00	171.00	163.00	140.00	149.00
	2ND:	205.00	206.00	201.00	177.00	151.00	145.00	141.00
	AVE:	205.50	206.50	203.00	174.00	157.00	142.50	145.00
DIST 40%	1ST:	223.00	218.00	220.00	216.00	206.00	186.00	167.00
	2ND:	222.00	222.00	217.00	220.00	194.00	187.00	150.00
	AVE:	222.50	220.00	218.50	218.00	200.00	186.50	158.50
DIST 50%	1ST:	235.00	232.00	231.00	230.00	226.00	224.00	208.00
	2ND:	238.00	237.00	232.00	231.00	222.00	227.00	196.00
	AVE:	236.50	234.50	231.50	230.50	224.00	225.50	202.00

TABLE C-6. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB3 BASE FUEL - (Continued)

VARIABLE		FOR BLEND (METHANOL (%) / ISOBUTANOL (%)) (0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)	(15/5)
DIST 60%	1ST:	248.00	247.00	244.00	242.00	240.00	239.00	228.00
	2ND:	252.00	251.00	248.00	245.00	238.00	245.00	215.00
	AVE:	250.00	249.00	246.00	243.50	239.00	242.00	221.50
DIST 70%	1ST:	264.00	264.00	262.00	258.00	256.00	255.00	248.00
	2ND:	268.00	269.00	265.00	266.00	258.00	258.00	235.00
	AVE:	266.00	266.50	263.50	262.00	257.00	256.50	241.50
DIST 80%	1ST:	290.00	287.00	288.00	284.00	280.00	279.00	274.00
	2ND:	289.00	291.00	286.00	292.00	284.00	278.00	261.00
	AVE:	289.50	289.00	287.00	288.00	282.00	278.50	267.50
DIST 90%	1ST:	326.00	321.00	327.00	319.00	317.00	320.00	311.00
	2ND:	326.00	324.00	327.00	330.00	331.00	316.00	311.00
	AVE:	326.00	322.50	327.00	324.50	324.00	318.00	311.00
DIST 95%	1ST:	362.00	356.00	358.00	353.00	357.00	352.00	339.00
	2ND:	373.00	364.00	364.00	372.00	365.00	350.00	356.00
	AVE:	367.50	360.00	361.00	362.50	361.00	351.00	347.50
DIST FBP	1ST:	411.00	403.00	399.00	401.00	397.00	399.00	393.00
	2ND:	408.00	411.00	407.00	414.00	405.00	401.00	401.00
	AVE:	409.50	407.00	403.00	407.50	401.00	400.00	397.00
RESIDUE %	1ST:	1.30	1.00	1.10	1.00	1.20	1.20	0.90
	2ND:	1.10	1.00	1.20	1.00	1.10	1.30	0.90
	AVE:	1.20	1.00	1.15	1.00	1.15	1.25	0.90
LOSS %	1ST:	0.60	0.50	0.70	0.01	0.01	0.60	0.01
	2ND:	0.60	0.70	0.80	0.30	0.50	0.60	0.10
	AVE:	0.60	0.60	0.75	0.15	0.25	0.60	0.05
V/L 5	1ST:	144.80	130.20	131.90	127.70	130.70	128.00	131.60
	2ND:	143.30	130.25	131.89	127.73	129.97	127.93	131.62
	AVE:	144.05	130.22	131.90	127.72	130.34	127.96	131.61
V/L 10	1ST:	148.60	133.80	135.50	128.70	131.70	128.80	132.60
	2ND:	149.03	133.87	135.47	128.71	131.89	129.34	132.56
	AVE:	148.81	133.89	135.48	128.70	131.80	129.07	132.58
V/L 15	1ST:	152.40	137.30	139.00	129.70	132.70	129.60	133.50
	2ND:	153.15	137.30	139.04	129.68	133.05	130.17	133.49
	AVE:	152.77	137.30	139.02	129.69	132.88	129.89	133.50
V/L 20	1ST:	156.20	140.80	142.60	130.60	133.70	130.40	134.40
	2ND:	156.86	140.82	142.61	130.65	134.02	130.87	134.43
	AVE:	156.53	140.81	142.61	130.62	133.86	130.63	134.41
V/L 25	1ST:	160.10	144.40	146.20	131.60	134.70	131.30	135.40
	2ND:	160.41	144.35	146.19	131.62	134.91	131.50	135.36
	AVE:	160.25	144.37	146.19	131.61	134.81	131.40	135.38
V/L 30	1ST:	163.90	148.20	149.80	132.60	135.70	132.10	136.30
	2ND:	163.88	148.27	149.76	132.59	135.77	132.11	136.29
	AVE:	163.89	148.29	149.78	132.60	135.73	132.10	136.30
V/L 35	1ST:	167.70	151.00	153.30	133.60	136.70	132.90	137.20
	2ND:	167.30	151.00	153.34	133.56	136.60	132.70	137.23
	AVE:	167.50	151.00	153.32	133.58	136.65	132.80	137.21
H_2O -15°C	1ST:		0.05	0.06	0.02	0.16	*******	0.30
	2ND:							
	AVE:		0.05	0.06	0.02	0.16	*******	0.30
H_2O 5°C	1ST:		0.05	0.07	0.08	0.26	0.09	0.45
	2ND:							
	AVE:		0.05	0.07	0.08	0.26	0.09	0.45
H_2O 20°C	1ST:		0.06	0.09	0.13	0.33	0.19	0.56
	2ND:							
	AVE:		0.06	0.09	0.13	0.33	0.19	0.56

*******Water separation occurred in original sample

TABLE C-7. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB4 BASE FUEL

MB4 + BASE BLEND 4

VARIABLE		FOR BLEND (METHANOL (•/•) / ISOBUTANOL (•/•)) (0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)	(15/5)
ALCOHOL ÷	1ST:	0			10.00	13.30		
	2ND:	0			10.00	13.30		
	AVE:	0			10.00	13.30		
RON	1ST:	98.40			100.20	100.30		
	2ND:	98.50			100.30	100.40		
	AVE:	98.45			100.25	100.35		
MON	1ST:	87.00			87.90	87.80		
	2ND:	87.00			87.70	87.90		
	AVE:	87.00			87.80	87.85		
R+M/2	1ST:	92.70			94.05	94.05		
	2ND:	92.75			94.00	94.15		
	AVE:	92.72			94.02	94.10		
•API	1ST:	56.00			55.40	55.20		
	2ND:	56.10			55.10	54.80		
	AVE:	56.05			55.25	55.00		
158•F ÷	1ST:	16.90			35.40	34.50		
	2ND:	17.00			33.60	33.60		
	AVE:	16.95			34.50	34.05		
ρ(LB/GAL)	1ST:	6.28			6.30	6.31		
	2ND:	6.28			6.31	6.32		
	AVE:	6.28			6.31	6.32		
AROMATICS	1ST:							
	2ND:	33.00			30.00	29.00		
	AVE:	33.00			30.00	29.00		
RVP	1ST:	7.30			10.60	10.20		
	2ND:	7.40			10.70	10.30		
	AVE:	7.35			10.65	10.25		
10÷ SLOPE	1ST:	3.10			0.80	1.00		
	2ND:	3.20			0.90	1.40		
	AVE:	3.15			0.85	1.20		
DIST IBP	1ST:	99.00			105.00	103.00		
	2ND:	100.00			108.00	105.00		
	AVE:	99.50			106.50	104.00		
DIST 5÷	1ST:	123.00			118.00	115.00		
	2ND:	124.00			122.00	116.00		
	AVE:	123.50			120.00	115.50		
DIST 10÷	1ST:	140.00			123.00	121.00		
	2ND:	141.00			126.00	124.00		
	AVE:	140.50			124.50	122.50		
DIST 15÷	1ST:	154.00			126.00	125.00		
	2ND:	156.00			131.00	130.00		
	AVE:	155.00			128.50	127.50		
DIST 20÷	1ST:	166.00			131.00	130.00		
	2ND:	168.00			135.00	134.00		
	AVE:	167.00			133.00	132.00		
DIST 30÷	1ST:	192.00			137.00	142.00		
	2ND:	193.00			144.00	145.00		
	AVE:	192.50			140.50	143.50		
DIST 40÷	1ST:	215.00			190.00	179.00		
	2ND:	217.00			200.00	182.00		
	AVE:	216.00			195.00	180.50		
DIST 50÷	1ST:	232.00			225.00	211.00		
	2ND:	234.00			229.00	213.00		
	AVE:	233.00			227.00	212.00		

TABLE C-7. INSPECTION DATA OF TRIAL BLENDS OF METHANOL GASOLINE BLENDS IN MB4 BASE FUEL - (Continued)

VARIABLE		FOR BLEND (METHANOL (•/•) / ISOBUTANOL (•/•)) (0/0)	(3/0)	(3/1)	(10/0)	(10/3.3)	(15/0)
DIST 60÷	1ST:	247.00			241.00	234.00	
	2ND:	249.00			245.00	238.00	
	AVE:	248.00			243.00	236.00	
DIST 70÷	1ST:	263.00			259.00	250.00	
	2ND:	263.00			262.00	255.00	
	AVE:	263.00			260.50	252.50	
DIST 80÷	1ST:	286.00			282.00	276.00	
	2ND:	288.00			285.00	280.00	
	AVE:	287.00			283.50	278.00	
DIST 90÷	1ST:	319.00			316.00	313.00	
	2ND:	320.00			322.00	315.00	
	AVE:	319.50			319.00	314.00	
DIST 95÷	1ST:	357.00			355.00	355.00	
	2ND:	359.00			365.00	360.00	
	AVE:	358.00			360.00	357.50	
DIST FBP	1ST:	404.00			400.00	394.00	
	2ND:	409.00			410.00	410.00	
	AVE:	406.50			405.00	402.00	
RESIDUE ÷	1ST:	1.00			0.80	0.80	
	2ND:	0.90			0.60	0.80	
	AVE:	0.95			0.70	0.80	
LOSS ÷	1ST:	0.90			0.70	0.80	
	2ND:	0.90			0.70	0.60	
	AVE:	0.90			0.70	0.70	
V/L 5	1ST:	172.80			115.10	120.70	
	2ND:	172.78			114.73	120.66	
	AVE:	172.79			114.91	120.68	
V/L 10	1ST:	176.10			116.30	122.10	
	2ND:	176.96			116.59	122.24	
	AVE:	176.53			116.44	122.17	
V/L 15	1ST:	179.30			117.50	123.50	
	2ND:	180.26			117.83	123.63	
	AVE:	179.78			117.66	123.57	
V/L 20	1ST:	182.60			118.60	124.80	
	2ND:	183.33			118.91	124.98	
	AVE:	182.96			118.76	124.89	
V/L 25	1ST:	185.80			119.80	126.20	
	2ND:	186.31			119.94	126.31	
	AVE:	186.05			119.87	126.26	
V/L 30	1ST:	189.00			121.00	127.60	
	2ND:	189.24			120.93	127.64	
	AVE:	189.12			120.97	127.62	
V/L 35	1ST:	192.30			122.10	129.00	
	2ND:	192.15			121.91	128.95	
	AVE:	192.23			122.00	128.98	
H2O -15•C	1ST:				0.01	0.18	
	2ND:						
	AVE:				0.01	0.18	
H2O 5•C	1ST:				0.08	0.27	
	2ND:						
	AVE:				0.08	0.27	
H2O 20•C	1ST:				0.13	0.33	
	2ND:						
	AVE:				0.13	0.33	

FIGURE C-1

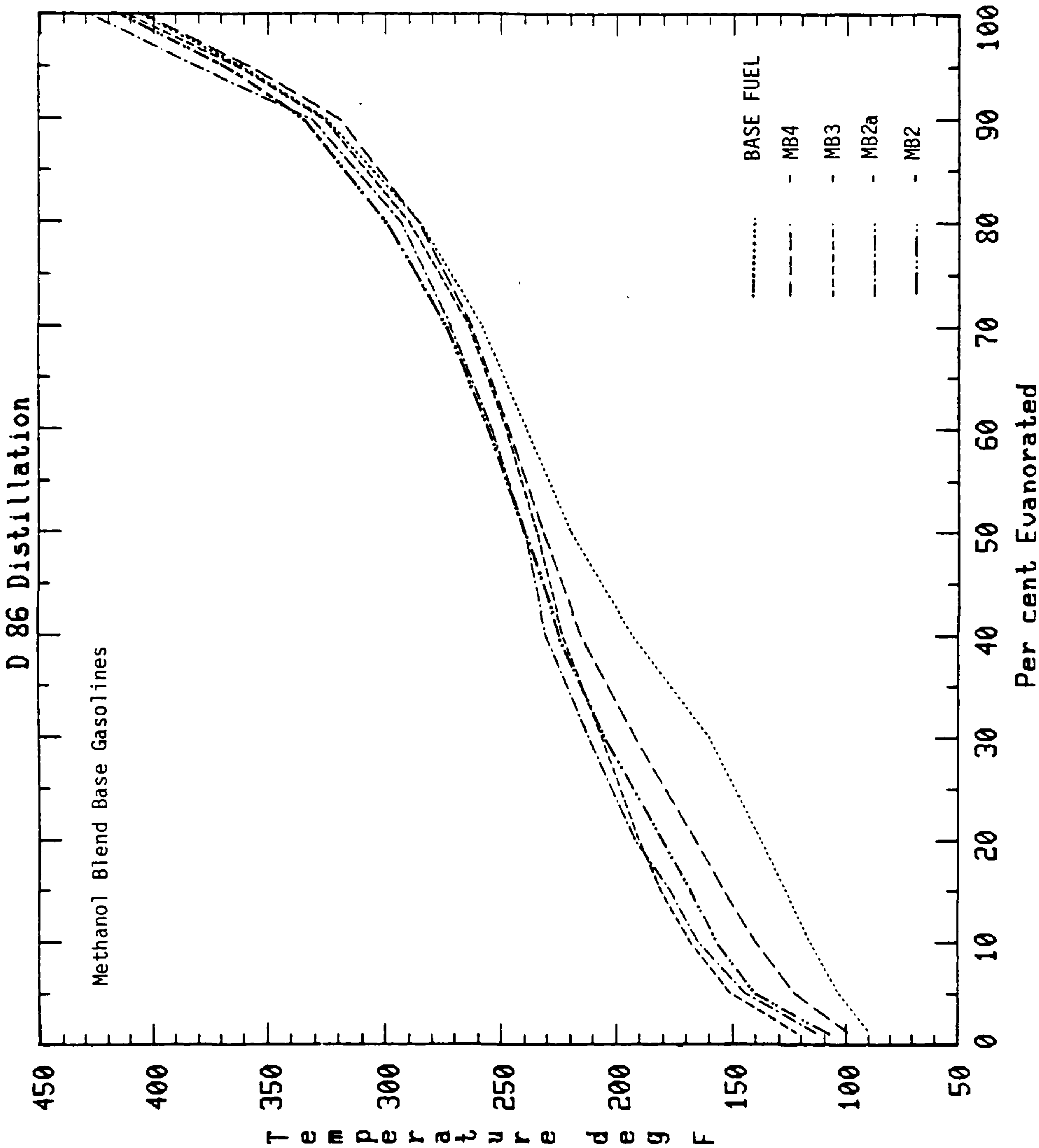

D 86 Distillation
Methanol Blend Base Gasolines
BASE FUEL
- MB4
- MB3
- MB2a
- MB2
Temperature deg F
450
400
350
300
250
200
150
100
50
Per cent Evanorated
0
10
20
30
40
50
60
70
80
90
100

FIGURE C-2

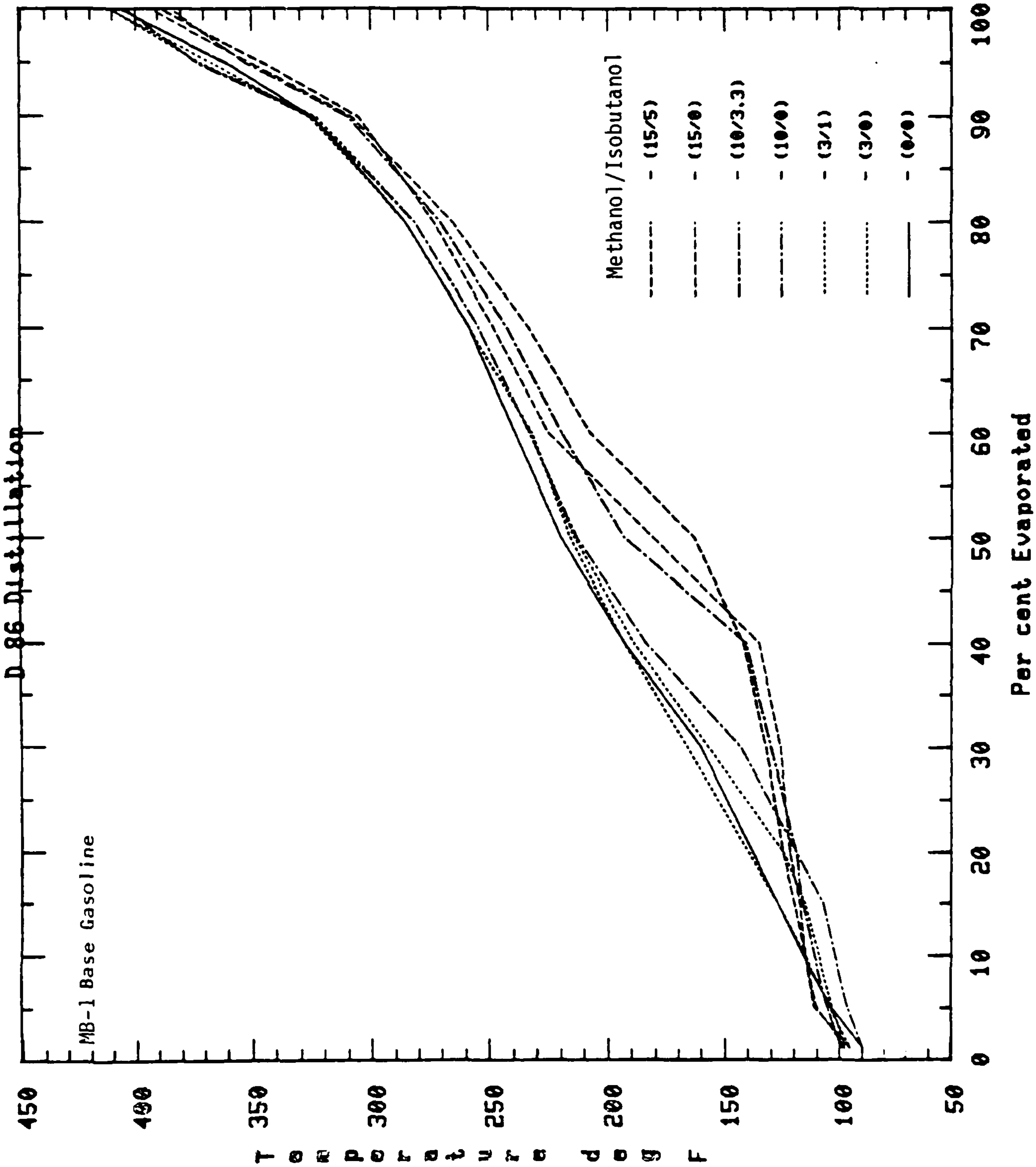

D 86 Distillation
MB-1 Base Gasoline
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Per cent Evaporated
0
10
20
30
40
50
60
70
80
90
100
Temperature deg F
50
100
150
200
250
300
350
400
450

FIGURE C-3

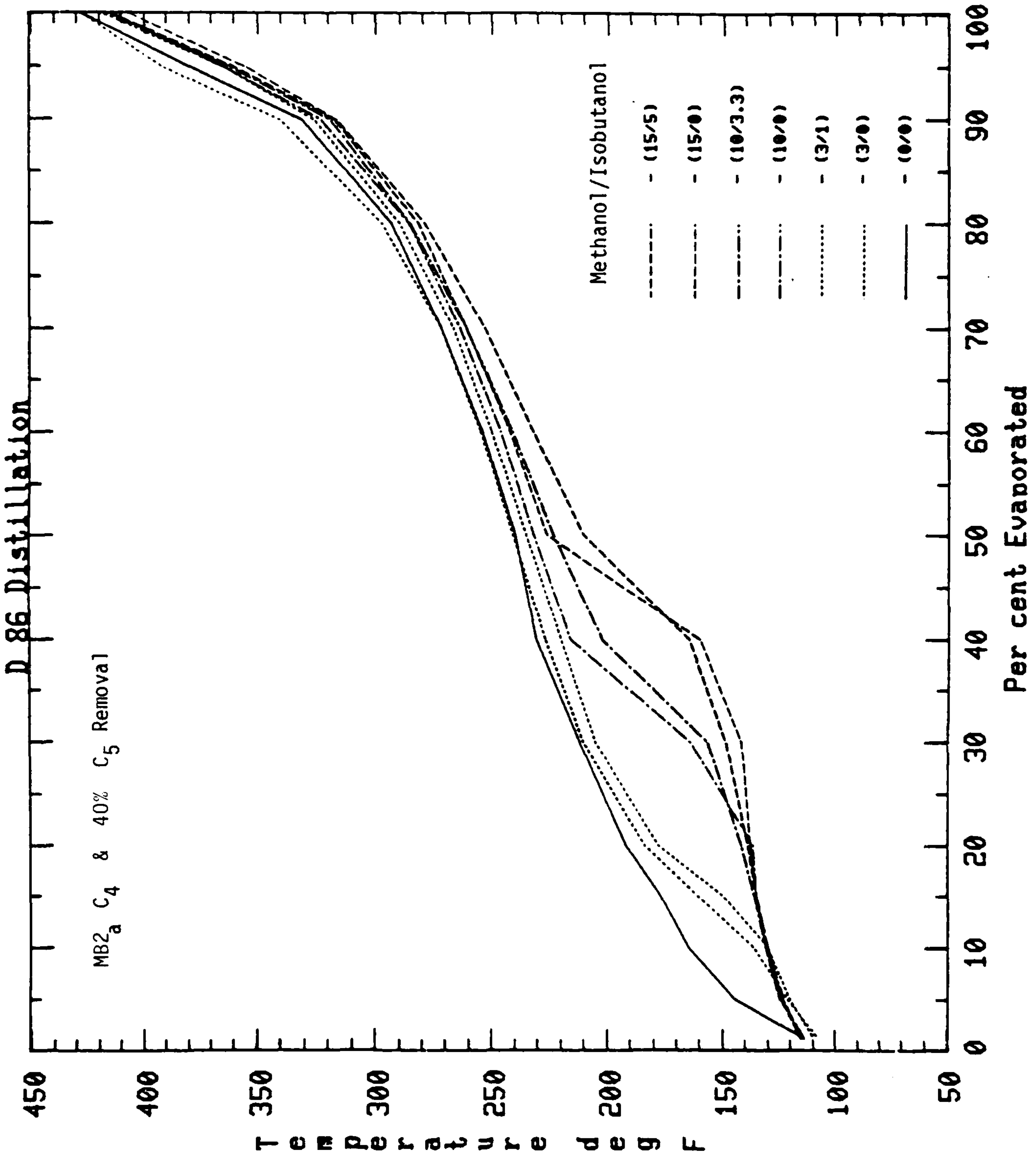

D 86 Distillation
MB2a C4 & 40% C5 Removal
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Per cent Evaporated
Temperature deg F
0
10
20
30
40
50
60
70
80
90
100
50
100
150
200
250
300
350
400
450

FIGURE C-4

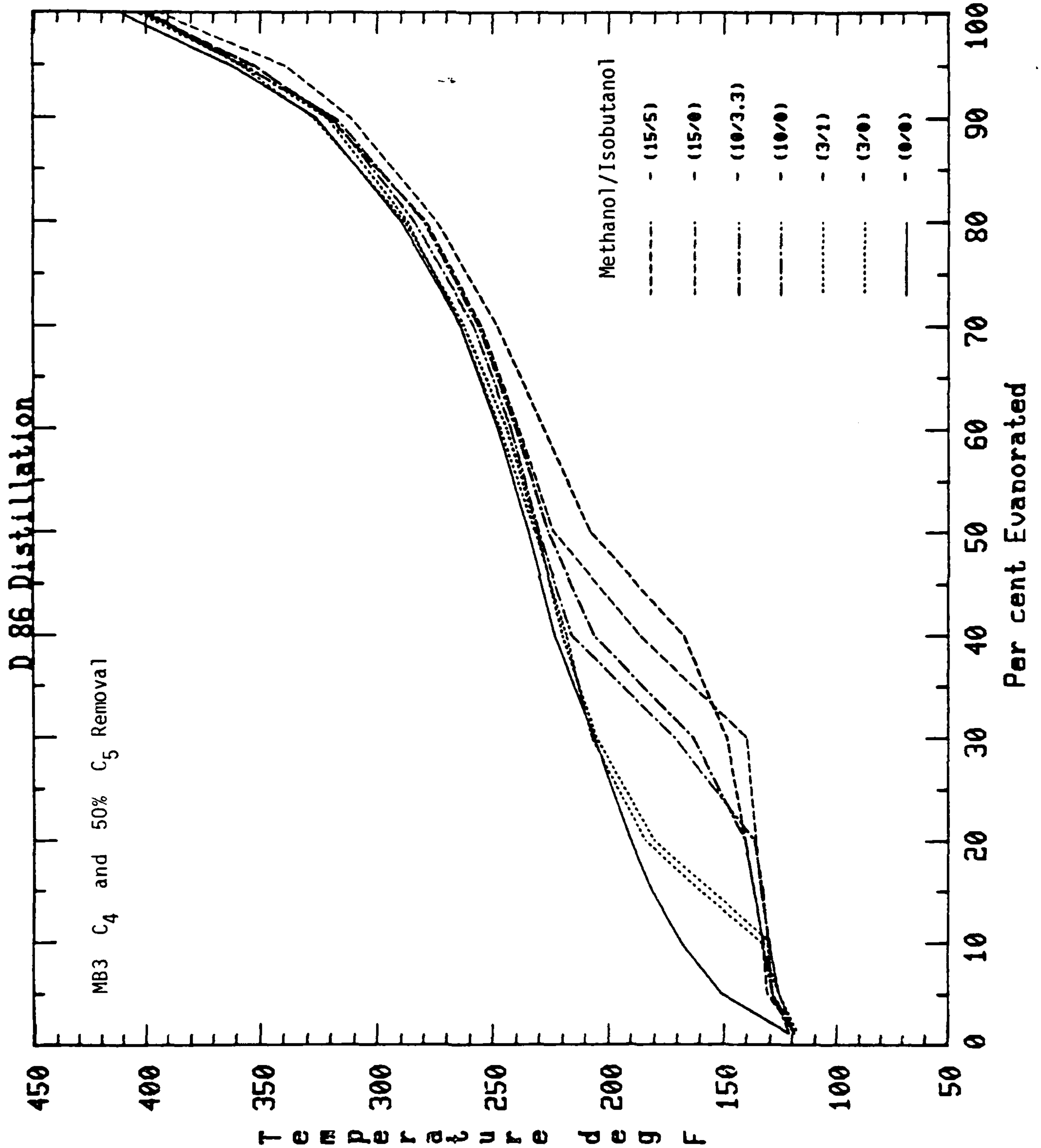

D 86 Distillation
MB3 C_4 and 50% C_5 Removal
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Per cent Evaporated
Temperature deg F
0
10
20
30
40
50
60
70
80
90
100
50
100
150
200
250
300
350
400
450

FIGURE C-5

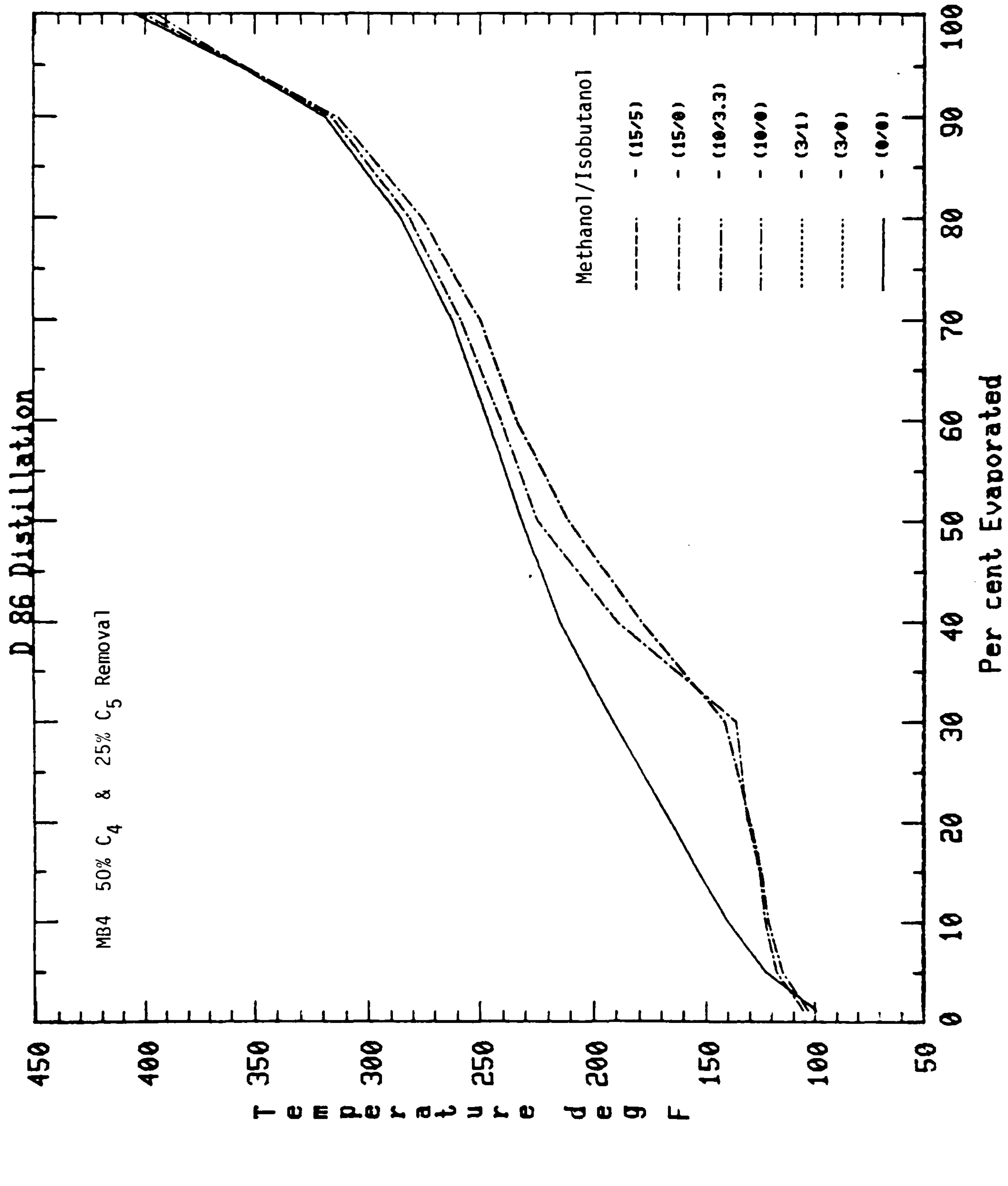

D 86 Distillation
MB4 50% C_4 & 25% C_5 Removal
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Temperature deg F
Per cent Evaporated
450
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
70
80
90
100

FIGURE C-6

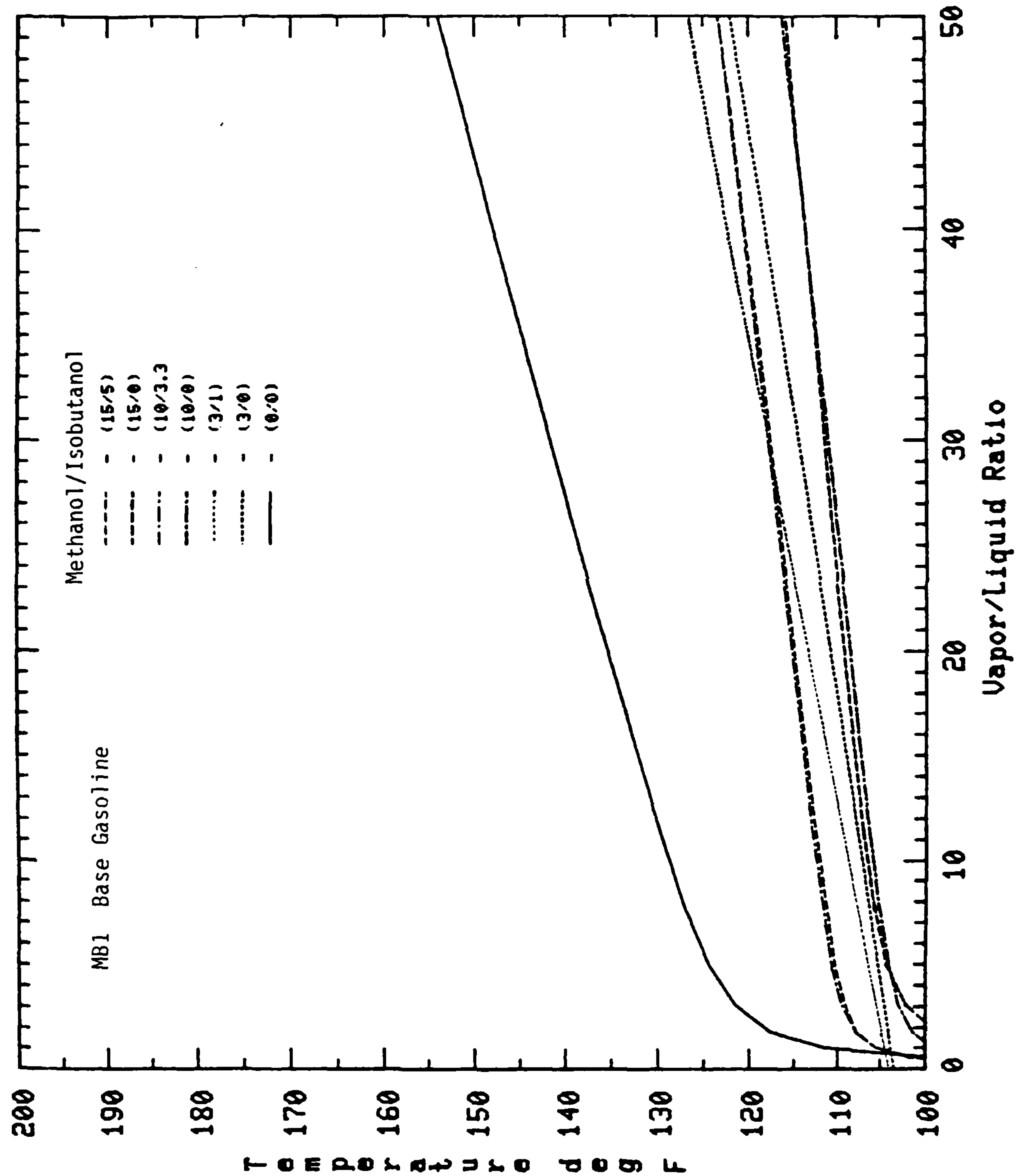

MB1 Base Gasoline
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Vapor/Liquid Ratio
Temperature deg F
0
10
20
30
40
50
100
110
120
130
140
150
160
170
180
190
200

FIGURE C-7

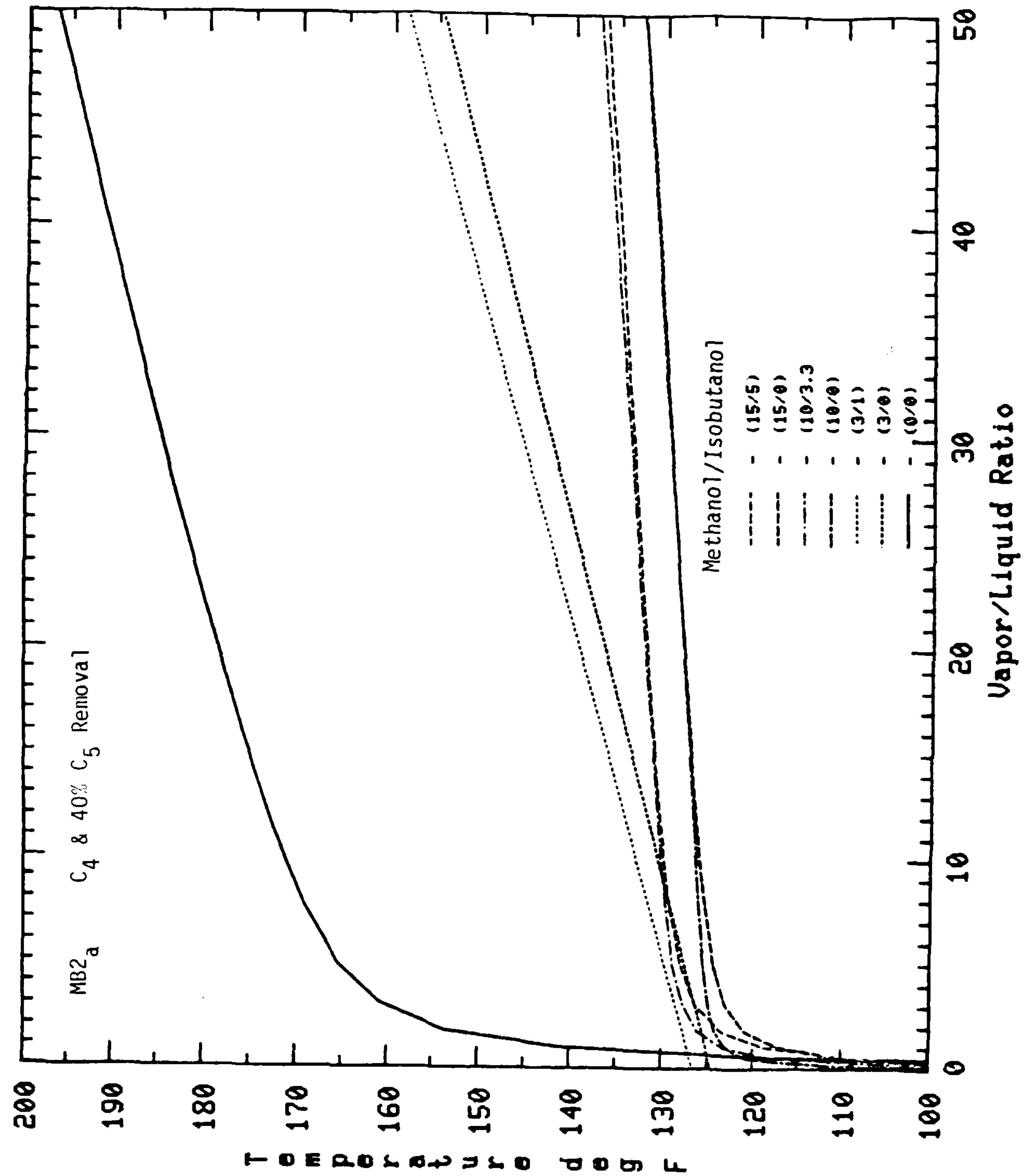
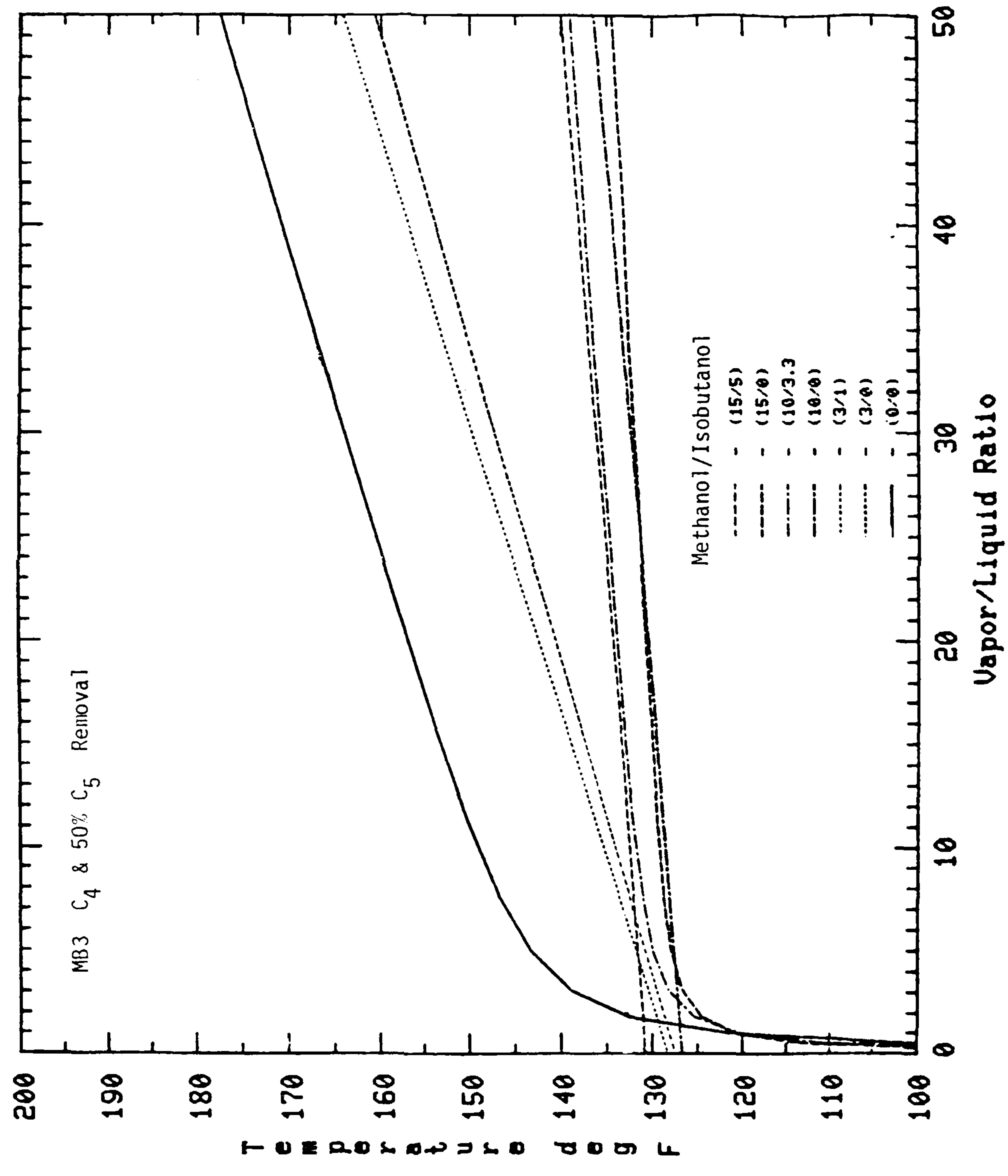

MB2a
C4 & 40% C5 Removal
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Vapor/Liquid Ratio
0
10
20
30
40
50
Temperature deg F
100
110
120
130
140
150
160
170
180
190
200

FIGURE C-8


MB3 C_4 & 50% C_5 Removal
Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Vapor/Liquid Ratio
0
10
20
30
40
50
Temperature deg F
100
110
120
130
140
150
160
170
180
190
200

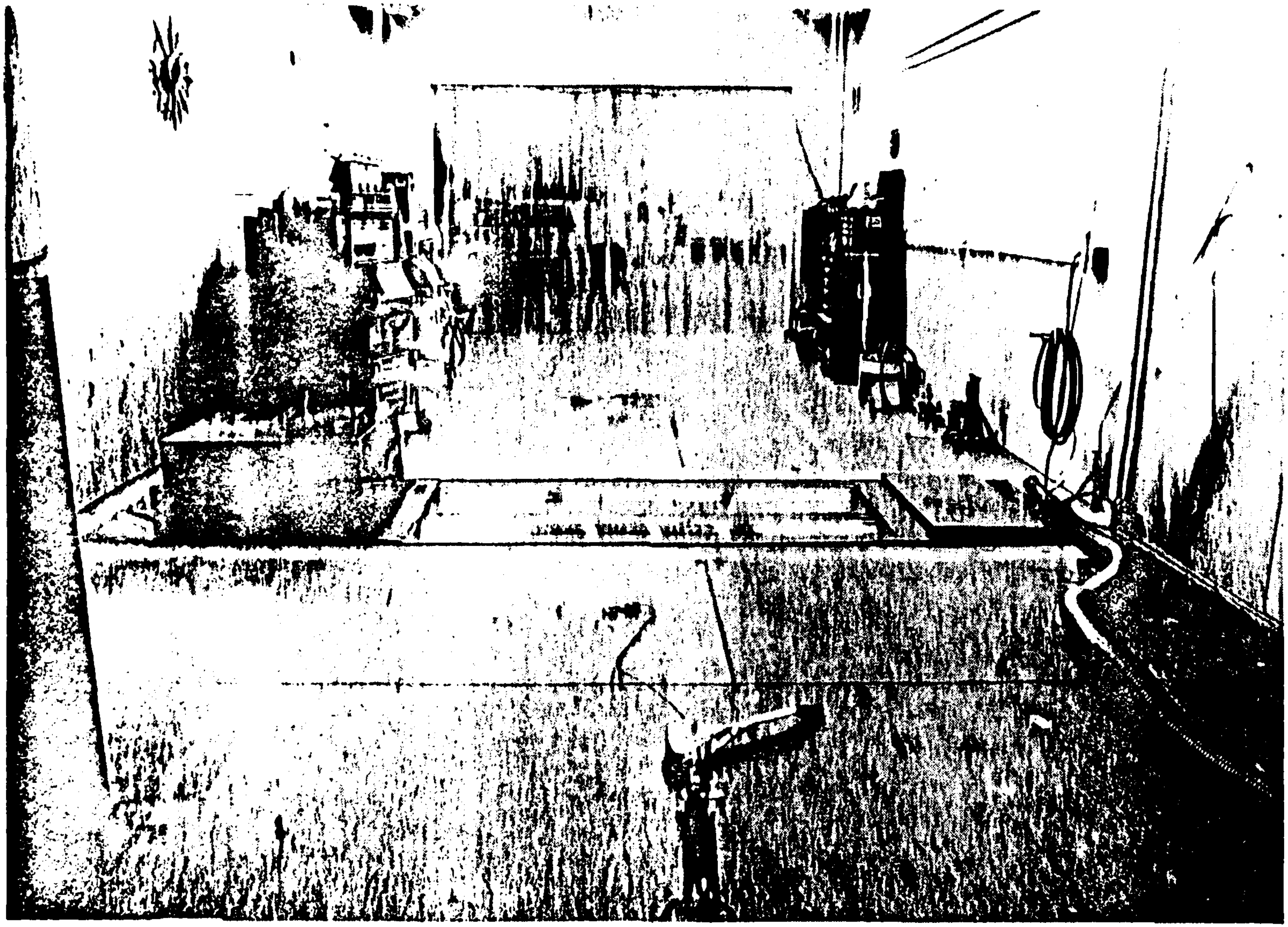


FIGURE D-4. PRECONDITIONING CELL AT SCI TEST FACILITY

In addition to the two emission test cells, a vehicle-preparation cell was used. This cell was equipped with a ECE-50 dynamometer, Horiba Mexa 300A HC/CO analyzers, and a Sun Model TET 945 engine analyzer. This cell was equipped with heating and cooling capacity to maintain temperatures between 68^{o}F and 110^{o}F within ±3^{o}F. An air curtain was used to isolate the closely controlled soak environment from the preparation cell. Figure D-4 shows the preparation cell.

D.1.2 Laboratory Equipment

All laboratory equipment at the Anaheim facility conformed to the requirements of the appropriate parts of Title 40, Code of Federal Regulations (CFR), Part 86.177. More specific details are set forth below.

D.1.2.1 Mass Emissions Instrument Systems

Both mass emissions instrument systems conformed to the requirements of 40 CFR 86.177-16. All sample-wetted components in the system were either of stainless steel or Teflon, except for the gas cylinder valves and regulators on gases other than nitric oxide (NO), which were brass. Figure D-5 illustrates one of the instrument systems. Each instrument system was equipped with the following instruments:

- Two Beckman Model 400 Flame Ionization Analyzers with ranges of 0-100 ppmC, 0-300 ppmC, 0-1000 ppmC, 0-3000 ppmC and 0-10,000 ppmC.
- One Bendix 8501-5C Analyzer with ranges of 0-100 ppm CO and 0-500 ppm CO.
- One Beckman 315B Analyzer with ranges of 0-3000 ppm CO, and 0-3 percent CO.
- One Beckman 315B CO Analyzer with ranges of 0-2.5 percent and 0-4.0 percent CO_2.
- One TECO 10 Chemiluminescence Analyzer with ranges of 0-100 ppm NO_x, 0-250 ppm NO_x, and 0-1000 ppm NO_x.
- Two Texas Instrument Servo-riter II dual-channel recorders for recording instrument signals.

A common calibration gas field was used for both instrument systems. Calibration curves were developed for each range of each instrument, using six gravimetric laboratory standards plus zero.

D.1.2.2 CVS System

Each of the two CVS systems conformed to the description of 40 CFR 86.177-16 and included a Mini-CVS(4) systems for engine-out samples. All sample-wetted components were either stainless steel, Teflon, or Tedlar. The air dilution filter carts were interconnected to both the CVS and to the vehicle tailpipe, using stainless-steel convoluted tubing. Adaptors of silicon rubber/fiberglass were used to seal the tubing to the tailpipe. A water-to-air type heat exchanger maintained the CVS pump inlet temperature to within ±10^{o}F of the

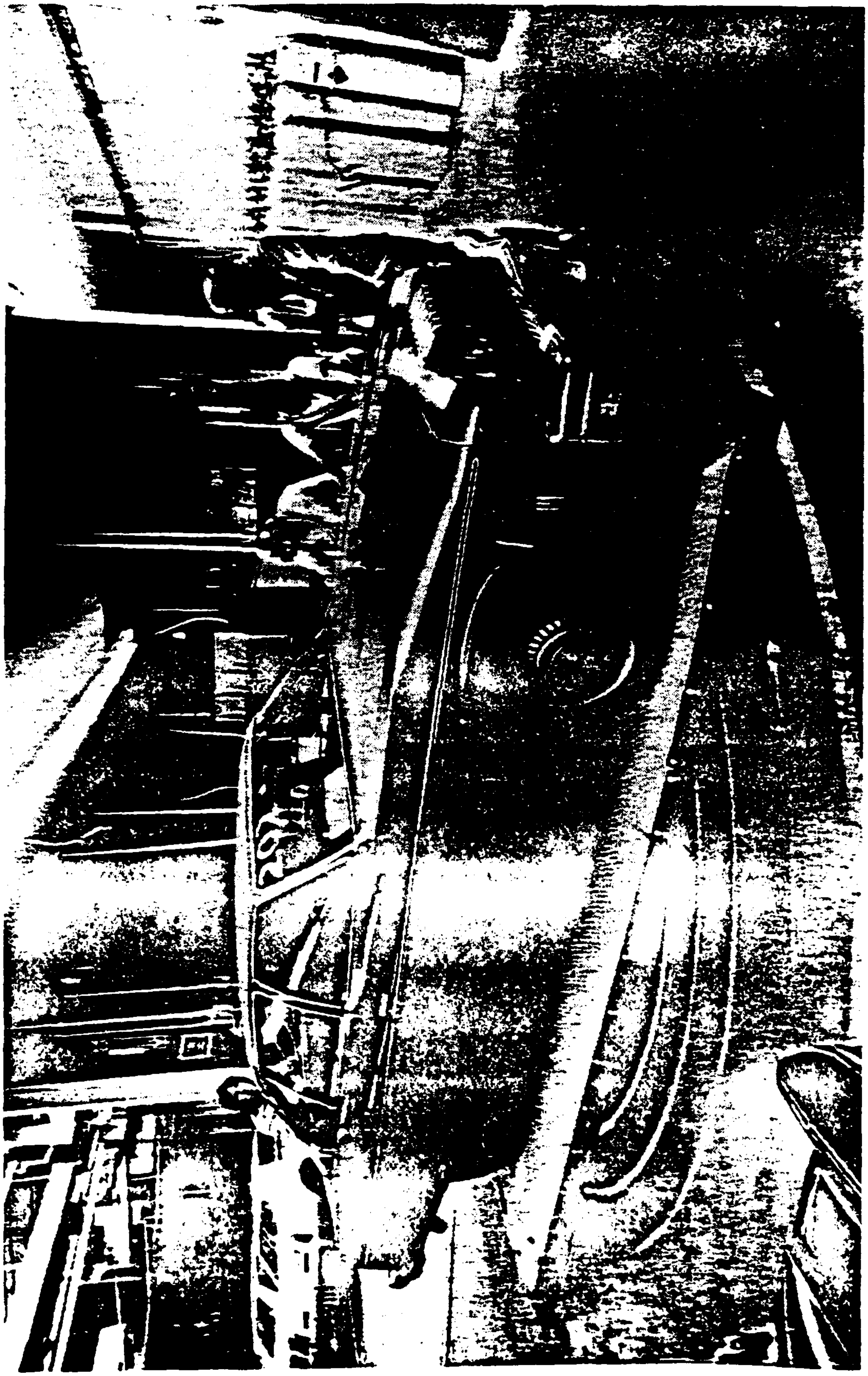


FIGURE D-3. SCI TEST FACILITY VEHICLE TURNTABLE

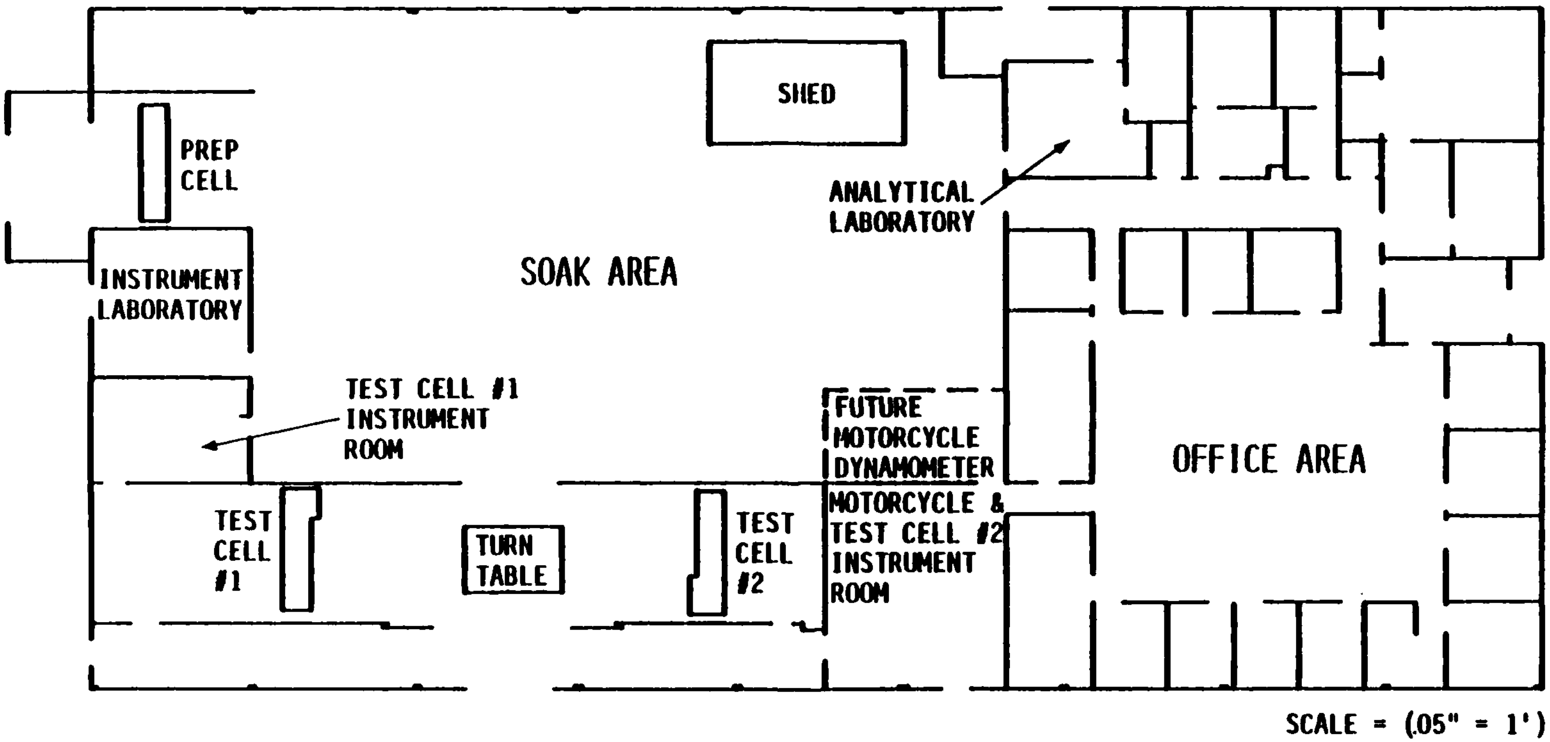


FIGURE D-2. SCI ANAHEIM LABORATORY

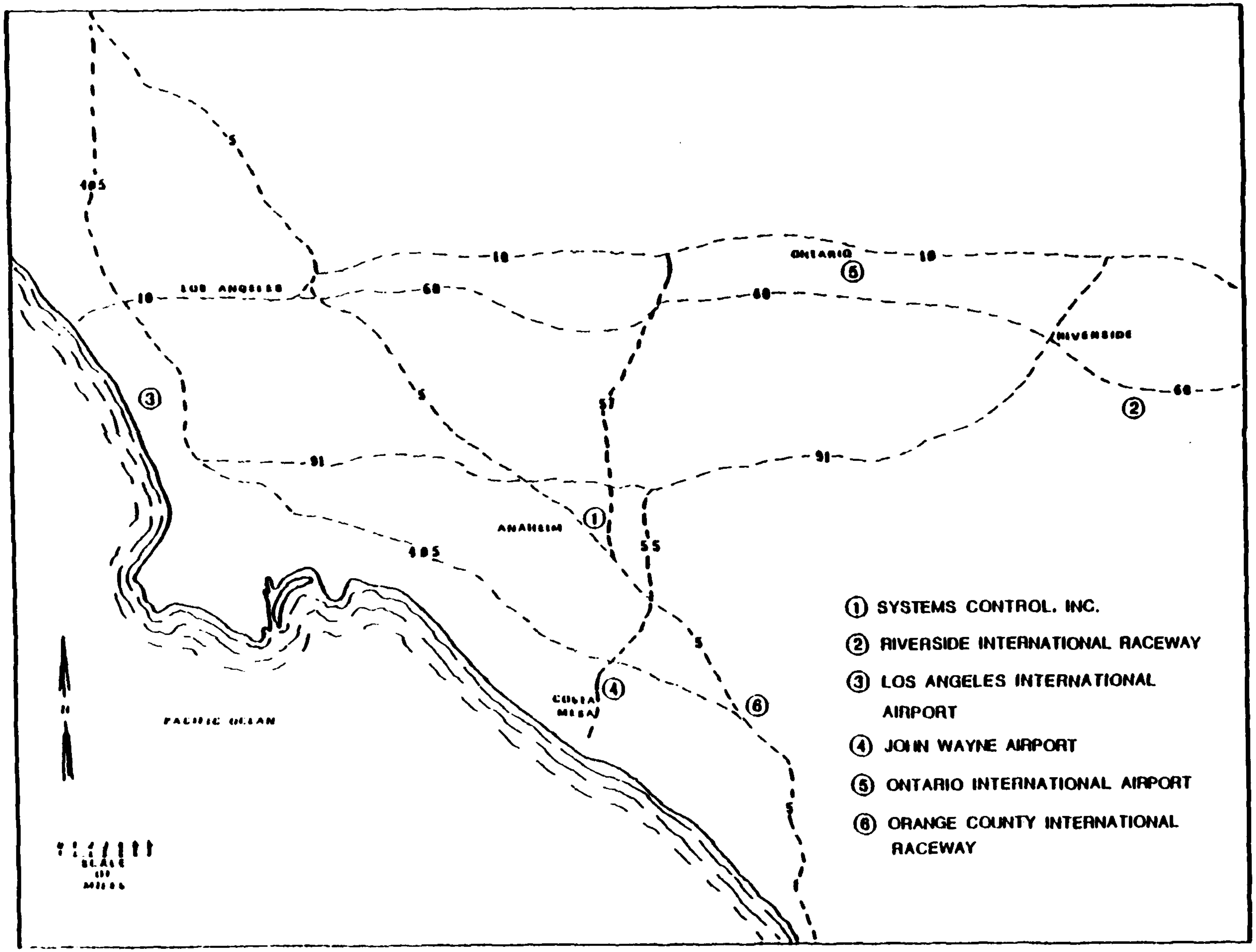


FIGURE D-1. LOCATION OF SYSTEMS CONTROL, INC.

Appendix D

TEST FACILITIES

This appendix describes the emission test facility and equipment employed on the DOE/CRC Alternative Automotive Fuels test program. Separate paragraphs are devoted to the following topics:

- Emission Laboratory
- Driveability Testing
- Vapor Lock Testing

D.1 EMISSION LABORATORY

The Environmental Engineering Division (EED) of SCI operates an emission-testing laboratory in Anaheim, California, where the DOE/CRC Alternative Automotive Fuels test program was conducted. The Anaheim laboratory has approximately 12,000 square feet of test cell and soak area. The facility also has approximately 5,000 square feet of air-conditioned office space which houses testing, quality control, and support personnel. Figure D-1 illustrates the location of the Anaheim facility. Modifications and improvements made to the facility for the CRC program included the following:

- Vapor lock test cell
- Analytical chemistry laboratory
- Sample collection system for aldehydes and alcohols emissions

D.1.1 Soak and Test Area

The Anaheim facility has over 4,000 square feet of area capable of maintaining fifteen vehicles in soak at one time. The soak and test temperatures were maintained by 130,000-Btu gas-fired heaters and 70 tons of air-conditioning equipment. Temperatures in the soak area were monitored continuously. In addition to temperature control, a humidification system was comprised of twenty-five Maid-of-the-Mist compressed air-driven spray nozzles and a reverse-osmosis desalination unit. This environmental-control system maintained soak and test-cell temperatures between 68°F and 74°F, and absolute humidity in the test cell between 20 and 50 grains of water per pound of air. Figure D-2 illustrates the facility layout.

There are two exhaust emission test cells within the facility, each totally independent of the other. These cells are equipped with exhaust-gas analyzers, dynamometers, and constant volume samplers, which are described in Section D.1.2. A 6,000-CFM fan in each test cell provides one air change every three minutes in each cell. A vehicle turntable, shown in Figure D-3, provided rapid vehicle movement into and out of the test cells.

APPENDIX D

TEST FACILITIES

TABLE C-13

INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
08B2

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	14.80	12.3	13.63	14.05	14.5		
ISOBUTANOL	2.22	1.8	-----	1.99	2.0		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	79.72		80.2	80.41	80.06	83.91	78.49
HYDROGEN	13.17		13.0	12.86	12.75	13.09	12.88
CARBON & HYDROGEN TOTAL	92.89		93.2	93.27	92.81	97.00	91.37
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	7.40	6.15	6.82	7.02	7.25		
ISOBUTANOL	0.48	0.39	0.00	0.43	0.43		
OXYGEN TOTAL	7.88	6.54	6.82	7.45	7.68		
CARBON &HYDROGEN & OXYGEN TOTAL	100.77		100.02	100.72	100.49		
D86 DISTILLATION, % EVAP @ F							
INITIAL	109	108	103	112	112		
10	126	125	124	122	127		
20	132	131	132	128	---		
30	137	138	138	133	138		
40	147	147	146	148	---		
50	212	206	206	209	214		
60	234	232	231	233	---		
70	252	253	251	253	254		
80	283	282	278	284	---		
90	318	309	317	321	319		
EP	401	400	385	414	405		
RVP, LBS	7.9	8.53	8.4	8.0	8.6		
GRAVITY, API	53.5	53.6	53.5	53.8	53.7	53.1	53.4
BTU/LB.							
GROSS						18,066	[illegible]
NET						16,972	[illegible]
BTU/GAL.							
GROSS						115,279	115,130
NET						107,660	107,64[illegible]
SULFUR CONTENT, %(W)LAMP						0.023	0.02[illegible]

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS:
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

TABLE C-12

INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
05B0

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	10.50	8.8	10.03	10.16	9.5		
ISOBUTANOL	NONE	0.0	----	NONE	0.0		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	81.67		81.8	82.38	83.16	80.49	80.56
HYDROGEN	13.07		13.0	12.71	12.07	13.66	12.76
CARBON & HYDROGEN TOTAL	94.74		94.8	95.09	95.23	94.15	93.32
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	5.25	4.40	5.02	5.08	4.75		
ISOBUTANOL	0.00	0.00	0.00	0.00	0.00		
OXYGEN TOTAL	5.25	4.40	5.02	5.08	4.75		
CARBON &HYDROGEN & OXYGEN TOTAL	99.99		99.82	100.17	99.98		
D86 DISTILLATION, % EVAP @ F							
INITIAL	107	114	104	107	111		
10	122	124	124	120	126		
20	128	130	130	125	---		
30	134	134	134	130	135		
40	198	195	196	197	---		
50	222	222	221	223	226		
60	234	238	238	238	---		
70	257	257	256	257	260		
80	284	285	282	298	---		
90	319	323	322	324	321		
EP	400	398	386	412	406		
RVP, LBS	8.1	8.70	8.7	8.4	8.9		
GRAVITY, API	54.4	54.1.	54.0	54.2	54.0	53.9	54.0
BTU/LB.							
GROSS						18,536	18,594
NET						17,290	17,430
BTU/GAL.							
GROSS						117,778	118,072
NET						109,860	110,683
SULFUR CONTENT ,%(W)LAMP						0.029	0.037

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS:
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

TABLE C-11

INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
05B3

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	9.65	7.9	9.01	9.40	8.8		
ISOBUTANOL	3.38	4.1	----	3.10	3.0		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	81.16		82.4	82.21	81.63	80.52	79.94
HYDROGEN	13.25		13.2	13.07	13.06	13.90	13.27
CARBON & HYDROGEN TOTAL	94.41		95.6	95.28	94.69	94.42	93.21
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	4.83	3.95	4.50	4.70	4.40		
ISOBUTANOL	0.73	0.89	0.00	0.67	0.65		
OXYGEN TOTAL	5.56	4.84	4.50	5.37	5.05		
CARBON & HYDROGEN & OXYGEN TOTAL	99.97		100.10	100.65	99.74		
D86 DISTILLATION, % EVAP @ F							
INITIAL	114	111	110	112	116		
10	129	128	128	126	131		
20	136	135	135	133	---		
30	154	155	150	156	160		
40	200	199	197	199	---		
50	218	217	217	219	222		
60	230	231	233	234	---		
70	254	249	251	253	258		
80	282	282	280	297	---		
90	324	324	327	330	325		
EP	400	400	397	416	409		
RVP, LBS	7.3	7.68	8.0	7.4	8.0		
GRAVITY, API	54.6	54.6	54.6	54.6	54.9	54.3	54.2
BTU/LB.							
GROSS						18,640	18,586
NET						17,372	17,375
BTU/GAL.							
GROSS						118,178	117,910
NET						110,138	110,227
SULFUR CONTENT, %(W)LAMP						0.039	0.021

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS;
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

TABLE C-10

INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
02B0

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	2.37	2.8	3.04	2.86	2.7		
ISOBUTANOL	NONE	0.0	----	NONE	0.0		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	85.32		85.5	85.93	85.64	84.99	84.43
HYDROGEN	12.62		13.0	12.72	12.73	13.95	12.92
CARBON & HYDROGEN TOTAL	97.94		98.5	98.65	98.37	98.94	97.35
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	1.19	1.40	1.52	1.43	1.35		
ISOBUTANOL	0.00	0.00	0.00	0.00	0.00		
OXYGEN TOTAL	1.19	1.40	1.52	1.43	1.35		
CARBON & HYDROGEN & OXYGEN TOTAL	99.13		100.02	100.08	99.72		
D86 DISTILLATION, % EVAP @ F							
INITIAL	106	108	104	105	107		
10	119	118	120	122	122		
20	152	151	147	157	---		
30	184	184	183	198	191		
40	208	209	210	216	---		
50	231	230	229	237	235		
60	247	246	246	253	---		
70	265	263	265	271	268		
80	292	289	291	297	---		
90	333	338	335	344	334		
EP	422	422	414	428	433		
RVP, LBS	8.1	8.71	8.7	8.3	8.9		
GRAVITY, API	54.3	54.1	54.0	54.2	54.3	54.0	53.7
BTU/LB.							
GROSS						19,358	19,256
NET						18,085	18,077
BTU/GAL.							
GROSS						122,923	122,487
NET						114,840	114,988
SULFUR CONTENT, %(W)LAMP						0.048	0.046

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS:
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

TABLE C-9

INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
02B1

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	3.24	3.8	4.02	3.23	3.8		
ISOBUTANOL	1.39	1.0	----	1.42	1.1		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	84.66		84.9	85.99	84.54	84.41	82.67
HYDROGEN	13.16		13.1	12.92	12.86	13.85	12.98
CARBON & HYDROGEN TOTAL	97.82		98.0	98.91	97.40	98.26	95.65
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	1.62	1.90	2.01	1.62	1.90		
ISOBUTANOL	0.30	0.22	0.00	0.31	0.24		
OXYGEN TOTAL	1.92	2.12	2.01	1.93	2.14		
CARBON & HYDROGEN & OXYGEN TOTAL	99.74		100.01	100.84	99.54		
D86 DISTILLATION, % EVAP @ F							
INITIAL	108	110	101	107	111		
10	125	124	121	122	126		
20	150	147	140	156	---		
30	186	186	180	188	191		
40	206	207	205	218	---		
50	225	224	222	225	227		
60	241	241	238	240	---		
70	259	260	256	262	261		
80	287	287	282	291	---		
90	322	324	324	330	322		
EP	404	403	398	415	410		
RVP, LBS	8.2	8.13	8.1	7.8	8.3		
GRAVITY, API	54.6	54.5	54.4	54.8	54.4	54.0	54.1
BTU/LB.							
GROSS						19,151	19,178
NET						17,887	17,994
BTU/GAL.							
GROSS						121,609	121,723
NET						113,582	114,209
SULFUR CONTENT, %(W)LAMP						0.020	0.045

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS;
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

TABLE C-8

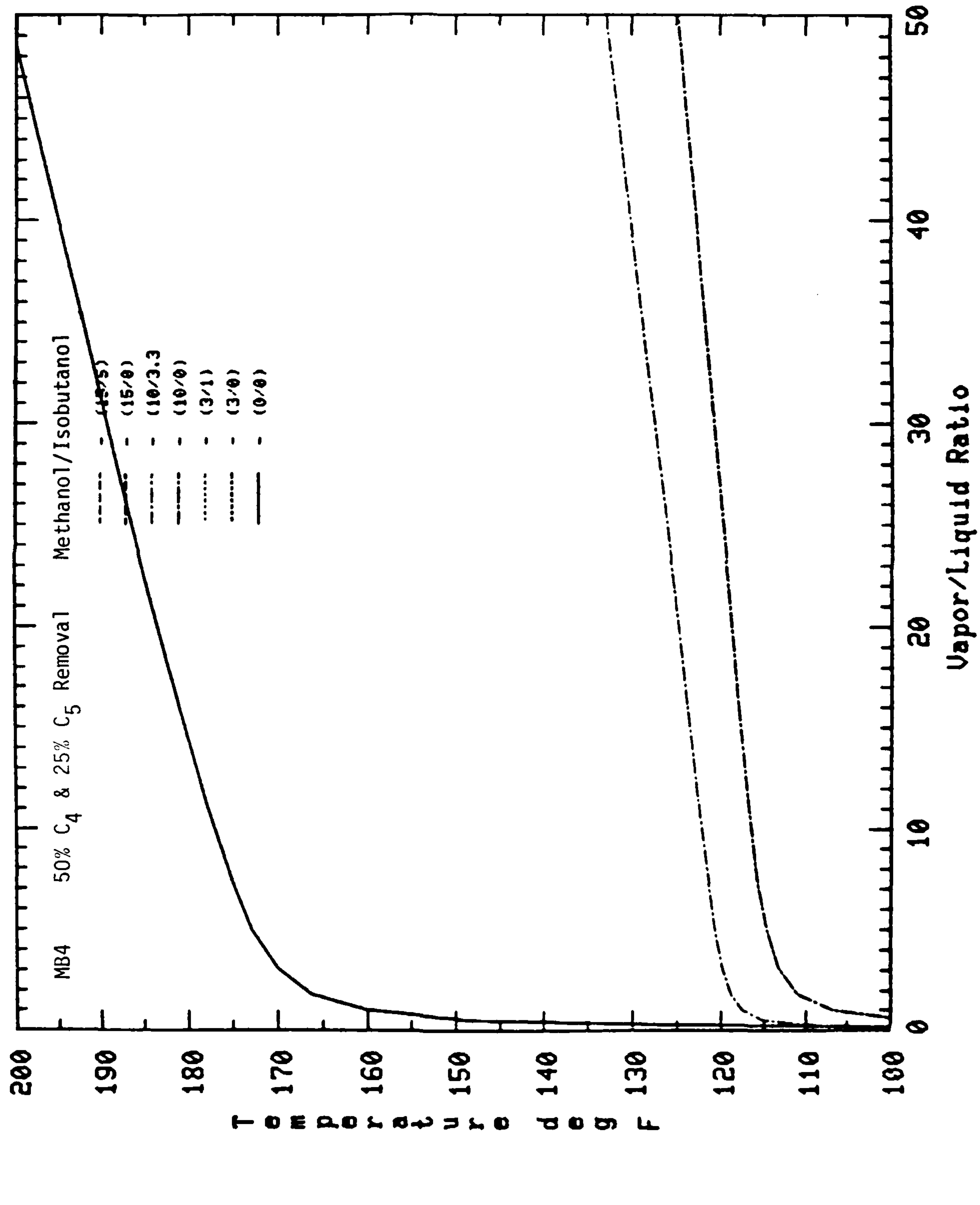
INSPECTION PROPERTIES OF ALTERNATIVE FUELS PROGRAM
PHASE II FUELS
BASE FUEL

	AMOCO	EXXON	MOBIL	TEXACO	SUNTECH	PHOENIX	PHOENIX(**)
ALCOHOL CONTENT, %(W)							
METHANOL	NONE	0.0	0.0	NONE	0.0		
ISOBUTANOL	NONE	0.0	0.0	NONE	0.0		
CARBON-HYDROGEN CONTENTS, %(W)							
CARBON	85.84		86.5	86.93	86.34	85.37	85.55
HYDROGEN	13.96		13.5	13.12	13.06	13.86	13.46
CARBON & HYDROGEN TOTAL	99.80		100.0	100.05	99.40	99.23	99.01
CALCULATED OXYGEN CONTENT, %(W)*							
METHANOL	0.0	0.0	0.0	0.0	0.0		
ISOBUTANOL	0.0	0.0	0.0	0.0	0.0		
OXYGEN TOTAL	0.0	0.0	0.0	0.0	0.0		
CARBON & HYDROGEN & OXYGEN TOTAL	99.40		100.0	100.05	99.40		
D86 DISTILLATION, % EVAP @ F							
INITIAL	93	86	80	89	92		
10	123	123	117	122	133		
20	146	146	142	150	---		
30	171	174	170	179	182		
40	199	201	198	207	---		
50	221	223	219	228	227		
60	236	237	234	243	---		
70	252	254	252	260	258		
80	277	279	276	286	---		
90	315	317	313	326	320		
EP	399	401	392	406	406		
RVP, LBS	8.8	9.87	9.3	9.1	9.6		
GRAVITY, API	59.6	59.2	59.3	59.1	59.6	58.4	58.7
BTU/LB.							
GROSS						19,803	19,796
NET						18,538	18,568
BTU/GAL.							
GROSS						122,838	122,597
NET						114,991	114,992
SULFUR CONTENT, %(W)LAMP						0.042	0.027

* OXYGEN CONTENTS WERE CALCULATED USING THE FOLLOWING FORMULAS:
METHANOL OXYGEN CONTENT = 1/2(METHANOL ALCOHOL CONTENT)
ISOBUTANOL OXYGEN CONTENT = 16/74(ISOBUTANOL ALCOHOL CONTENT)

** DUPLICATE TEST RESULTS

FIGURE C-9


MB4 50% C4 & 25% C5 Removal Methanol/Isobutanol
- (15/5)
- (15/0)
- (10/3.3)
- (10/0)
- (3/1)
- (3/0)
- (0/0)
Temperature deg F
200
190
180
170
160
150
140
130
120
110
100
Vapor/Liquid Ratio
0
10
20
30
40
50

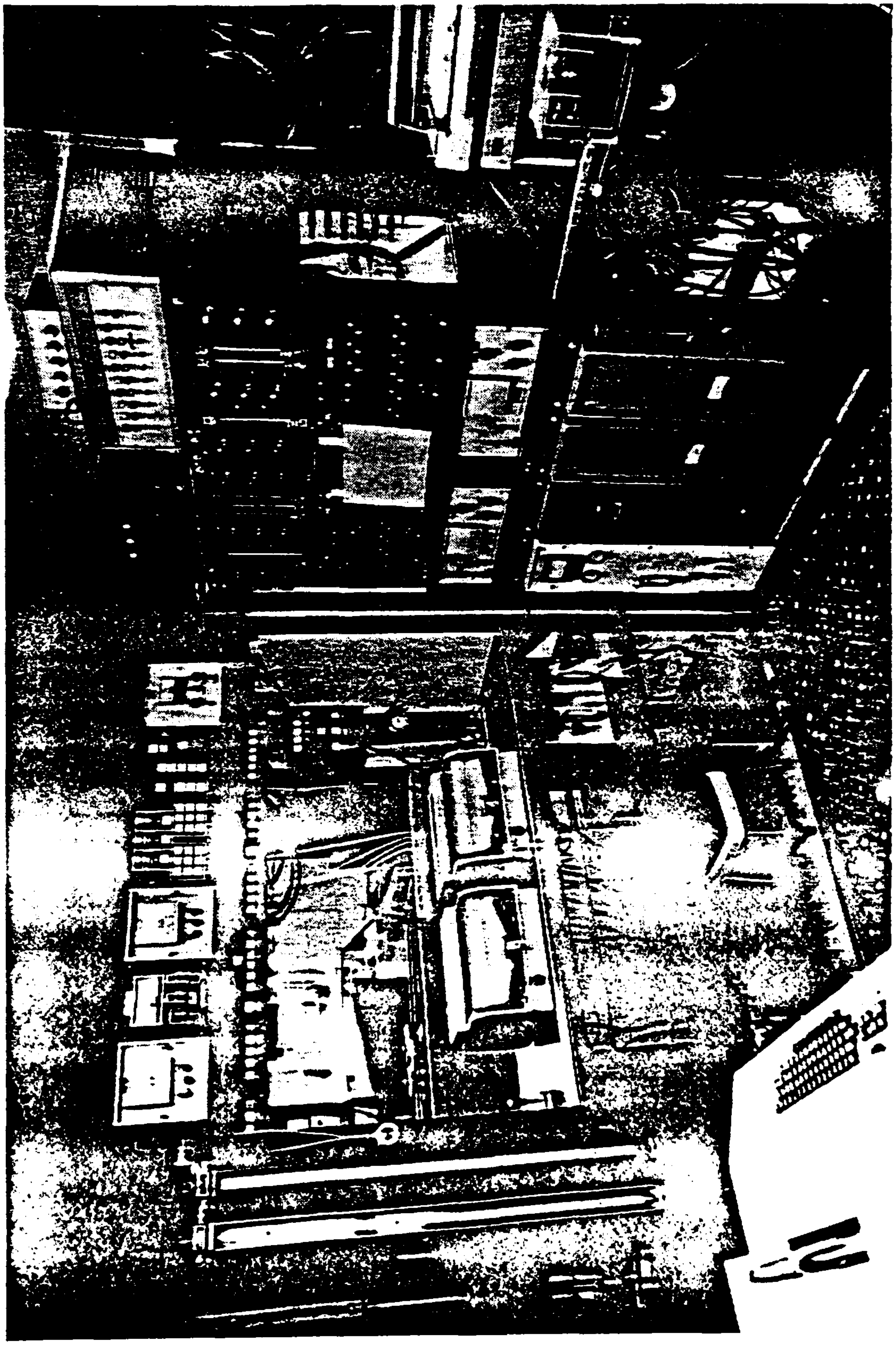


FIGURE D-5. ANALYTICAL INSTRUMENT LABORATORY AT SCI TEST FACILITY

nominal set point (110^{o}F). Both CVS systems contained nine Tedlar sample collection bags (three utilized for the engine-out samples), each with a usable volume of 10 cubic feet. Filling of the sample bags was remotely controlled by computer. Figure D-6 illustrates one of the CVS systems, showing dilution air filter cart, CVS, and bag rack.

The CVS systems in each cell were modified to permit collection of alcohol and aldehydes samples. Alcohol samples were collected in 10-liter Tedlar bags mounted in separate bag racks. Three separate bags were used for each phase of the FTP, and a fourth bag was used for background air sample thoughout the FTP. Aldehydes samples were collected in graduated cylinders fitted with fritted glass-tipped bubblers. Three bubblers in series were used for each phase of the FTP and background. Figure D-7 shows the aldehyde bubblers and alcohol sample bags. After sample collection, the aldehyde bubblers and alcohol-sample bags were carried from the test to the analytical laboratory.

D.1.2.3 Chassis Dynamometer

The two chassis dynamometers used for emission testing were Clayton Model ECE-50-0, utilizing a 1,750-pound Direct Drive Variable Inertia Flywheel (DDVIF) unit. The roll-set spacing was 17.2 inches between rolls. The DDVIF provided eleven inertia weight settings in 250-pound increments from 1,750 pounds to 3,000 pounds, and 500-pound increments from 3,000 pounds to 5,550 pounds. The dynamometer in one test cell was equipped with 125-pound increments and was capable of testing front-wheel drive vehicles. The dynamometers were not equipped for automatic load control.

A digital voltmeter (DVM) indicating miles per hour was used to monitor the dynamometer front- or rear-roll speed. A digital meter, calibrated and scaled to read out directly indicated horsepower within ±0.1 horsepower, was used to monitor the power absorption unit. Separate revolution counters were used to count and store each segment of the FTP. By multiplying the number of revolutions over the segment by the circumference, the distance traveled was computed accurately.

D.1.2.4 Driver's Aid

The driver's aid was a computer-controlled, Hewlett-Packard recorder onto which the FTP driving cycle was traced by a Hewlett-Packard computer. This hard copy of the desired trace showed all significant events during the cycle, such as cranking, idle, transmission-in-gear, engine shut-off, and bag-switching times. The computer also printed out the crank-time and total test time for the FTP. The driver's aid was also equipped to record dynamometer load and front-roll speed during coastdown calibrations and load setting before and after tests. The driver's aid cabinet also included indicator lights which informed the driver and operator of equipment status.

D.1.2.5 Computer System

A Hewlett-Packard Model 2114A was used as the mass emission test system controller. The computer system was a real-time interrupt system, and controlled the functions of both the driver's aid and the CVS. The system operator, using a teletype, entered the test to be conducted and descriptive information. The test driver, using a push-button pendant, started the test from the vehicle.

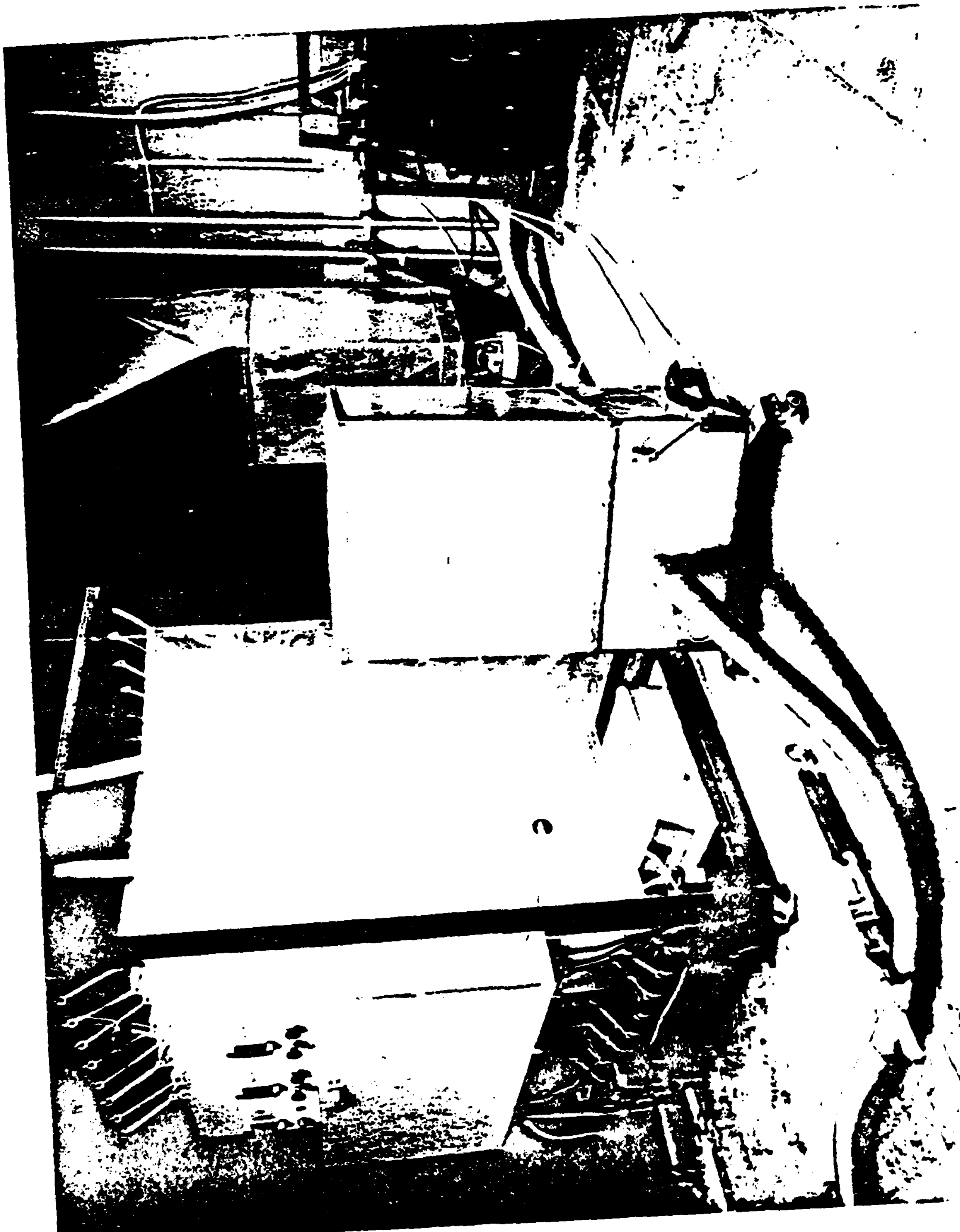


FIGURE D-6. TEST FACILITY CVS SYSTEM

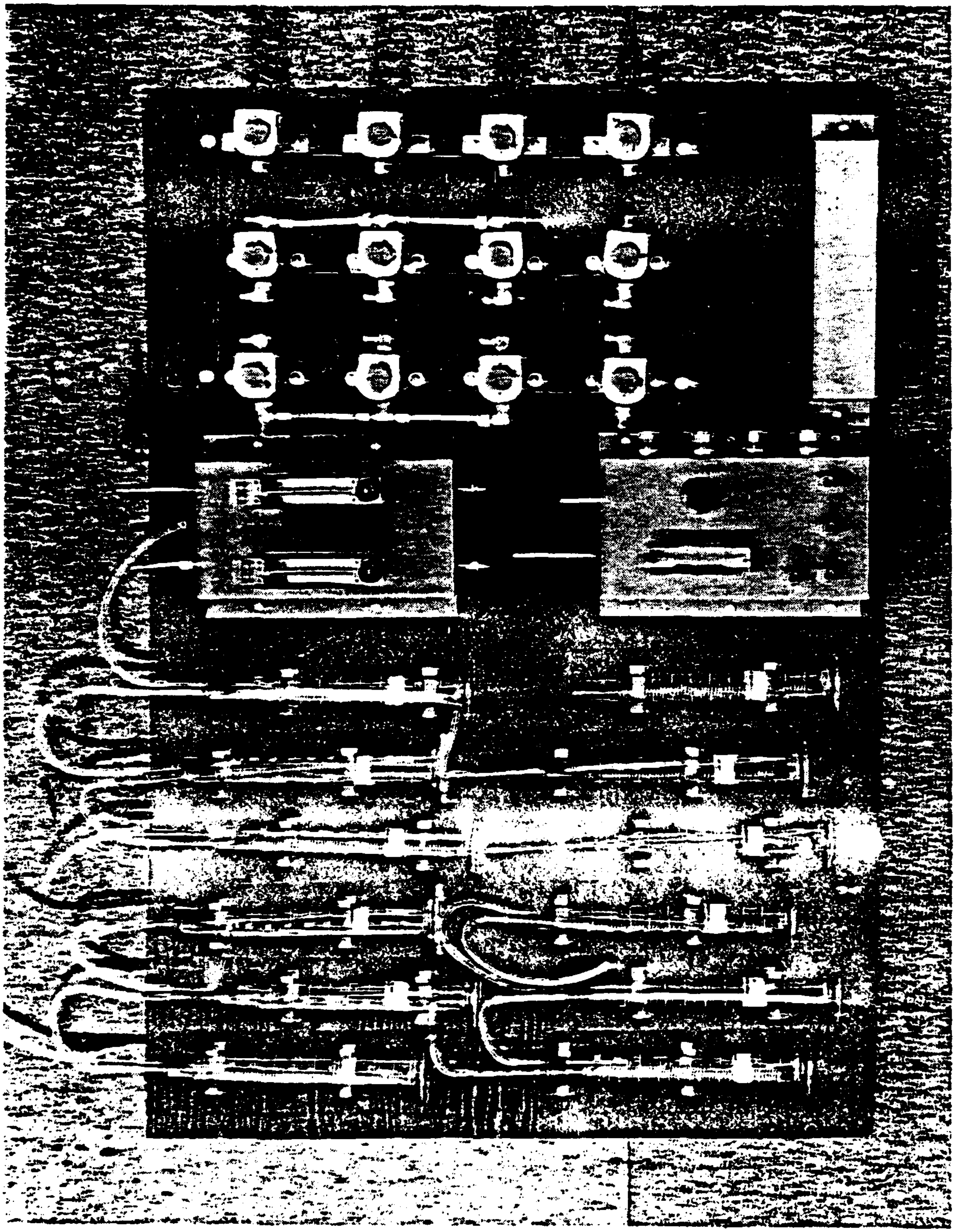


FIGURE D-7. ALDEHYDE AND ALCOHOL SAMPLING SYSTEM

After initiation of the test, i.e., engine cranking, all sampling functions were controlled by the computer system. Bag analysis, however, was performed manually.

D.1.2.6 Evaporative Emissions SHED System

A Horiba Model 5 SHED, shown in Figure D-8, was constructed within the Anaheim facility. The SHED met all specifications of SAE Report J-17-A and specifications of the Code of Federal Regulation (CFR), Part 40, Subpart B, Section 86.107-78. The SHED featured extended length and width for greater volume and a water-to-air heat exchanger for greater internal ambient-temperature stability. A single 1000-CFM blower provided a circulation rate of approximately 1/2 SHED volume per minute through the heat exchanger. The SHED was fabricated using anodized aluminum panels for the walls, floor, and ceiling, and Tedlar panels in the ceiling to provide for minor volume changes. The door was of one-piece construction and pivoted from the top out and upward. Pneumatic cylinders operated the door for opening or closing. An air-inflated silicone rubber gasket was used to seal the door when closed. A 5000-CFM fan built into the SHED provided purging of the SHED between tests. The purge fan discharge was diverted out of the building to prevent contamination of test facility ambient air.

The SHED Analytical System met all the requirements of the 40 CFR 86.107-78 and included the HC Analyzer, recorder, sampling subsystem and diurnal temperature controls, and readout devices. The SHED Analyzer was a Scott Model 116 HC analyzer. The Model 116 provided ranges of 50 ppmC, 100 ppmC, 300 ppmC, 1,000 ppmC, and 3,000 ppmC. Linear six-point calibration curves plus zero were used for each range. A 60/40 blend of hydrogen/helium was used for FID fuel, and zero-grade air for combustion air.

A two-pen, Texas Instruments Servo-riter II recorder was used to record both the analyzer output and the SHED ambient temperature. A rate-of-rise temperature controller was also incorporated in the SHED Analytical System. This controller produced the 0.4°F/sec rate-of-rise of the tank fuel temperature and remained within ±3°F temperature error band. The tank fuel target and actual temperature were recorded on a second two-pen recorder.

The SHED Analytical System included 10-liter Tedlar bags and sampling system to permit collection of alcohol samples from the SHED.

D.1.2.7 Other Laboratory Instruments and Equipment

Additional supportive instruments and equipment which were used for this program included:

- Merriam Model 50MC2-4F Laminar Flow Element including manometers, timers, and temperature meters for CVS calibration.

- Sargent-Welch Cat. No. S-4565 Mercury column barometers for ambient-pressure measurement in the test cells.

- Sargent-Welch Cat. No. S-4655 continuous automatic-recording, temperature-compensated barograph for recording barometric pressures continuously over a 1-week period. Calibration error was less than ±0.04 cm

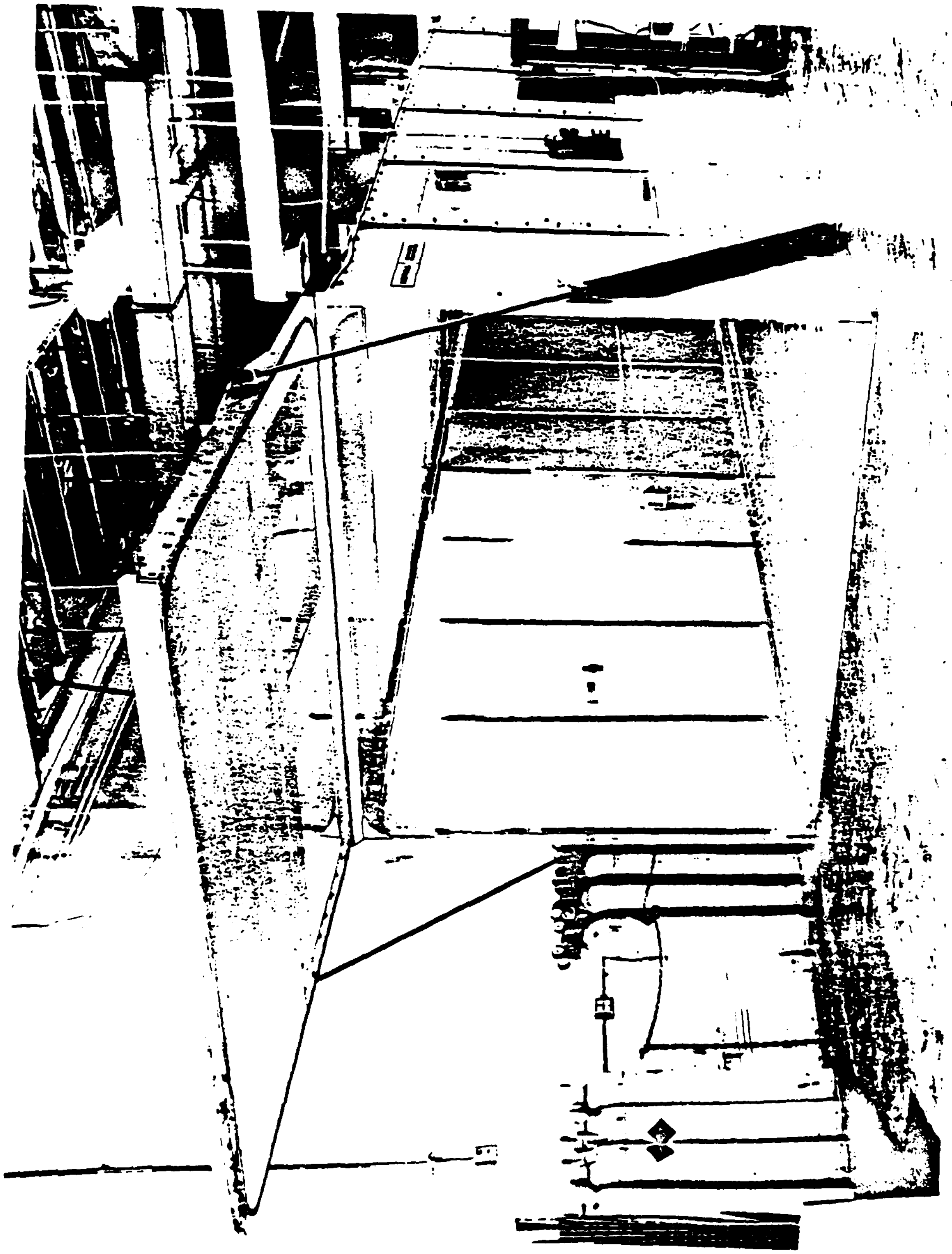


FIGURE D-8. SHED AT SCI TEST FACILITY

Hg, and measurement error was less than ±0.06 cm Hg over the measurement range of 71 cm to 79 cm of mercury.

- Rustrak recorders for continuous recording of soak-area temperature, wet and dry bulb temperature at the vehicle-cooling inlet fan in the test area, and CVS pump inlet temperature.
- Sargent Welch portable motorized psychrometer for spot-checks of soak- and test-area temperatures and humidity.
- Sun Model TET 945 engine-parameter diagnostic scope (an Autoscan Model 4000 was used earlier in the CRC program).
- Two Sargent-Welch Cat. No. S-42610 motor-ventilated hygrometers for monitoring wet/dry bulb temperatures, modified for continuous recording.
- Water manometers for measurement of CVS inlet pressure and ΔP of the CVS pump.
- Two Mettler Model 1200 precision balances for propane recovery tests.
- Two Hartzell Model N24-DUW cooling fans (instrumented with the motor-ventilated hydrometers).
- A refrigerated fuel-storage shed and dispensing SHED for pre-conditioning barrels of fuel prior to opening and for storage after opening.
- Two 5,000-gallon underground fuel tanks for storing Indolene and break-in mileage accumulation fuel.
- Maxon vehicle lift rated at 7,000 pounds.
- A fenced security area at the rear of the facility to provide parking for up to twenty-five vehicles.

D.1.3 Analytical Laboratory

The analytical laboratory was equipped as follows to determine the concentrations of methanol, ethanol, and aliphatic aldehydes in diluted vehicle exhaust and in SHED air samples:

- Two Carle Instruments, Inc. Series R Analytical Gas Chromatographs (GC) provided automatically programmed gas-sampling valves for repeatable gas sampling and analysis and accelerated backflush-to-waste. These GC's were used for methanol and ethanol determinations. The GC is shown on the left of Figure D-9.
- Two Carle Instruments, Inc. Omniscribe Model 7302 dual-pen recorders, each with solid state electronic integrators provided both the peak height and integrated waveforms of the GC's outputs. The recorder is shown on the right of Figure D-9.

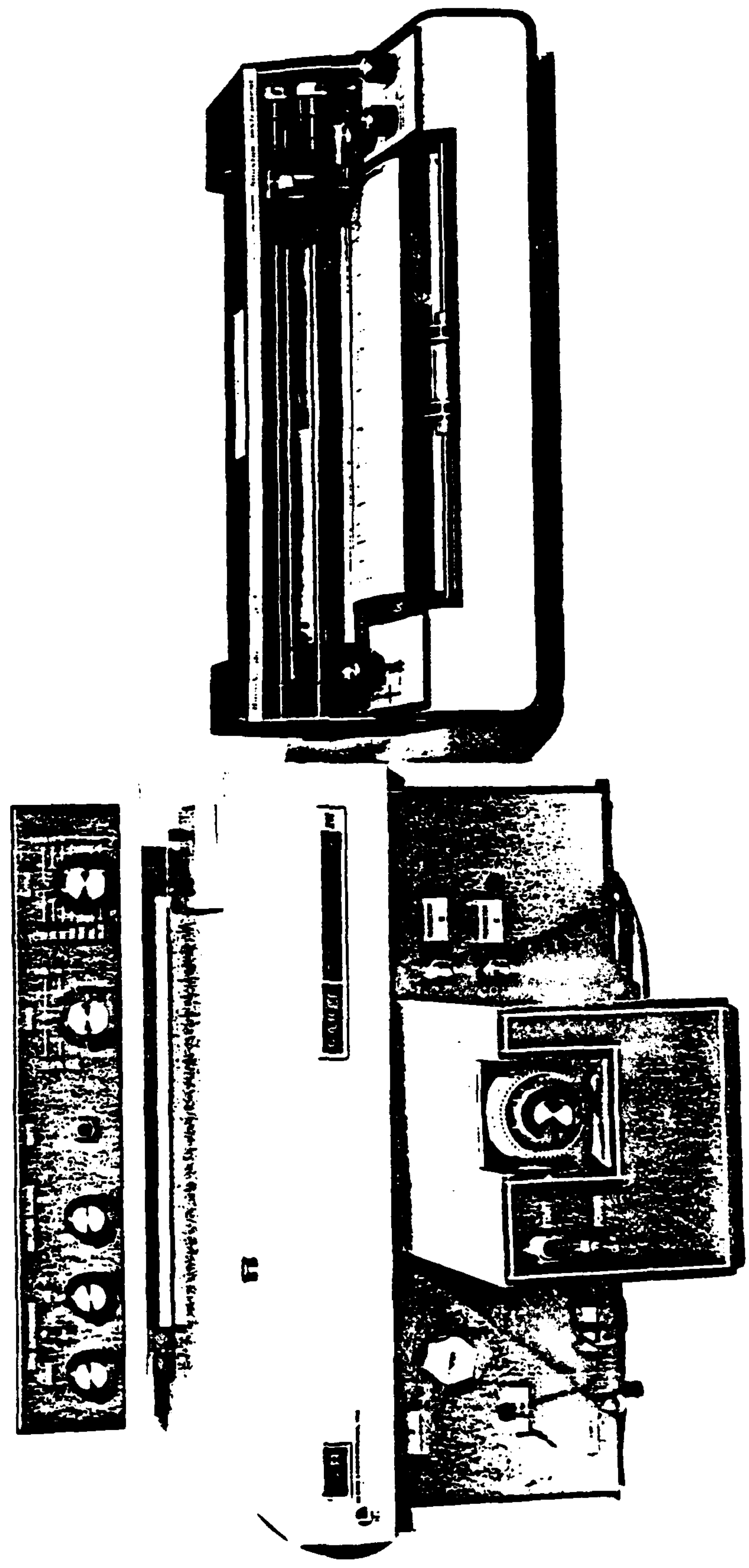


FIGURE D-9. GAS CHROMATOGRAPH AND RECORDER

- One Bausch and Lomb Spectronic 20 Spectrophotometer was used for colorimetric analysis of total aliphatic aldehydes absorbed in MBTH reagent.

The GC's were equipped with two columns: 1) a stripper column to remove the majority of interfering hydrocarbons, and 2) an alcohol selective column for separating ethanol and methanol. The stripper column was packed with GE Silicone SF 96, coated on Chromosorb T (Teflon), a nonadsorptive highly inert support which minimized tailing of the alcohol peaks. The SF 96 was a non-polar liquid phase which separated the test sample according to boiling point. Those compounds with boiling points greater than ethanol (C_7 hydrocarbons and higher in general) were backflushed-to-vent, while methanol, ethanol, and organics with boiling points below ethanol were eluted to the downstream selective column. The selective column was packed with Carbowax 1540 coated on Chromosorb T. Carbowax 1540 was a polyethylene glycol, a polar liquid phase with selectivity for polar compounds such as alcohols and other oxygenated organics. The Carbowax 1540 had little affinity or selectivity for the C_6 and lower hydrocarbons that passed through the stripper column. They eluted quickly as a composite peak early on the chromatogram. Methanol and ethanol were retained and eluted as separate peaks.

During the development phase, the column system was carefully tested to ensure that methanol and ethanol were positively separated from the most probable interfering compounds. The instrument was tested on pure methanol and ethanol headspace. Hexanes and heptane were added to ensure that the proper boiling-point cuts were being made on the stripper column. Benzene was verified as not interfering. Although pure-hydrocarbon interferences were eliminated with a high degree of certainty, there was the possibility of interference of low molecular weight oxygenated organics. It was unlikely, however, that they would elute exactly coincident with the methanol or ethanol peaks on a Carbowax column of this length. Auto exhaust from unleaded gasoline was run, though, and found to have trace levels of methanol and ethanol present.

D.2 DRIVEABILITY TESTING

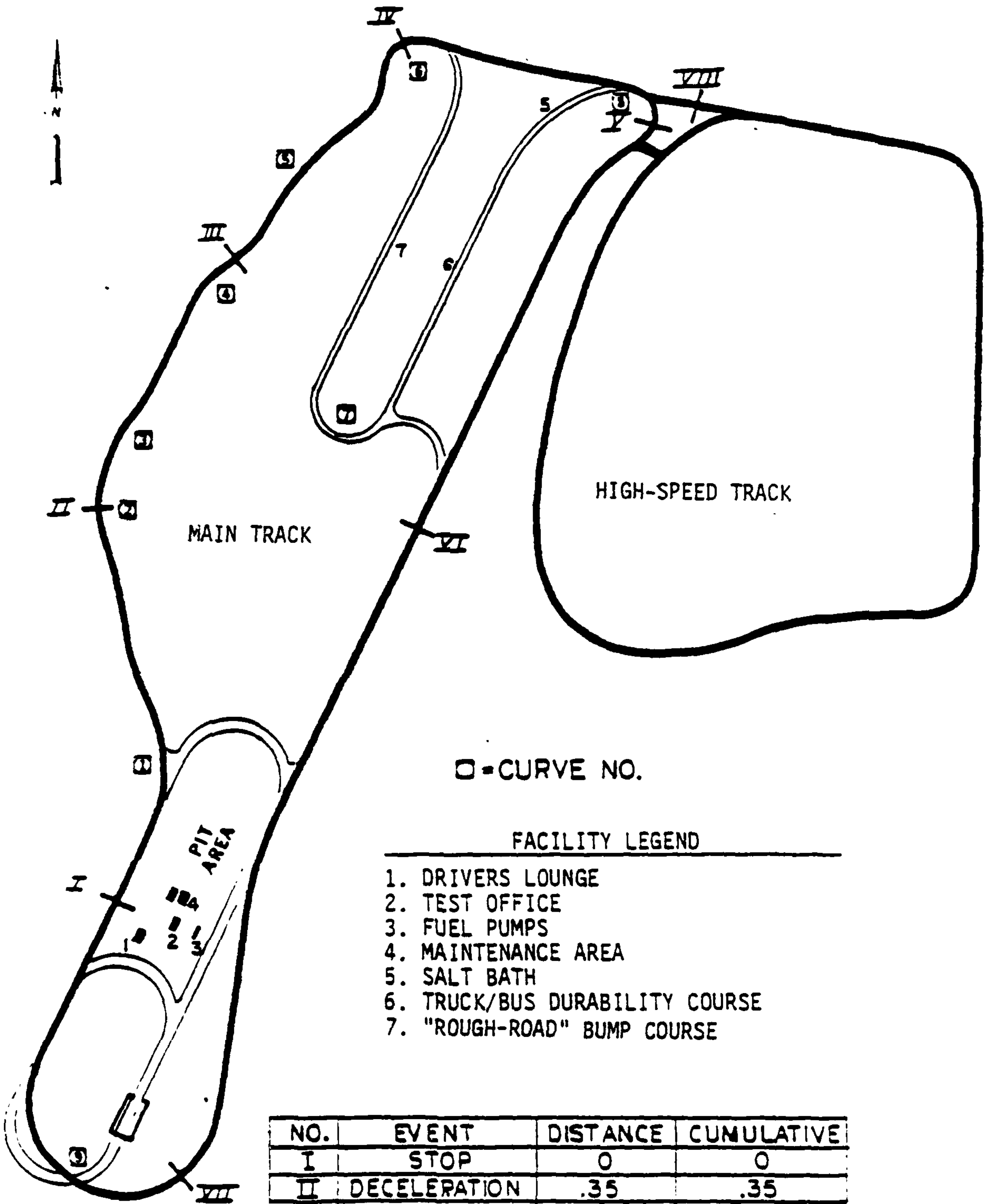
The track consisted of a nine-curve main touring course, plus a 1.6-mile high-speed oval with four banked curves, as shown in Figure D-10. Event markers for driveability testing were placed on the main track betwen curves 8 and 9. Vehicles were parked in the pit area adjacent to the track for overnight soaks.

In addition to the track proper, Riverside International Raceway offered the following facilities:

- Six gasoline-dispensing pumps with Bendix 0-50971 gasoline filters/ water separators, and six 10,000-gallon underground tanks in the garage area.

- Fenced and secured storage area for all test vehicles, and garage facilities for vehicle maintenance and service.

- Lounge for instruction and briefing of drivers and observers.



NO.	EVENT	DISTANCE	CUMULATIVE
I	STOP	0	0
II	DECELERATION	.35	.35
III	STOP	.30	.65
IV	DECELERATION	.20	.85
V	STOP	.26	1.11
VI	DECELERATION	.50	1.61
VII	DECELERATION	.64	2.25
I	STOP	.37	2.62
VIII	STOP	.80	1.60

FIGURE D-10. DRIVEABILITY TEST TRACK

- Office space for SCI supervisory personnel.
- Weather station for continuously recording ambient temperature, wind speed, wind direction, and humidity.

D.3 VAPOR LOCK TESTING

The vapor lock test was performed in a test cell rather than on the road, due to the need to maintain 110°F temperature at various times during the year. The test cell was the vehicle-preparation cell described in Section D.1, and included a twin-roll ECE-50-0 dynamometer computer and driver's aid. The cell computer was programmed to draw the driving schedule and to sense and record the acceleration times. The test-cell temperature-control system was modified to provide ±2°F of set-point temperature of 70°F and 100°F.

APPENDIX E

TEST PROCEDURES

TEST PROCEDURES

Appendix E, Test Procedures, is available for inspection at the CRC office.

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - MPGCOMB

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	7.089	1.418	19.135	.000
Groups	1	13.721	13.721	2.547	.186
Models	2	556.569	278.284	51.665	.001
FxG	5	.623	.125	1.680	.185
FxM	10	6.288	.629	8.487	.000
GxM	2	23.130	11.565	2.147	.233
FxGxM	10	2.147	.215	2.897	.021
Cars(GxM)	4	21.545	5.386	55.852	.000
FxC(GxM)	20	1.482	.074	.768	.739
Error	60	5.787	.096		
Total(adj)	119	638.380			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

Model	Fuel					
	Base	MG1	MG2	MG3	MG4	MG5
O, 4-1, 4-2	26.501(4)	26.630(4)	26.459(4)	26.470(4)	26.273(4)	25.903(4)
O, 6-1	21.887(2)	21.086(2)	20.659(2)	19.755(2)	20.140(2)	19.475(2)
O, 4-3, 4-4	21.638(4)	21.672(4)	21.622(4)	21.180(4)	21.427(4)	21.296(4)

Closed Loop

Model	Fuel					
	Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	24.606(4)	25.055(4)	24.122(4)	24.782(4)	24.846(4)	24.642(4)
C, 6-1	21.730(2)	21.161(2)	21.314(4)	20.671(2)	20.680(2)	20.494(2)
C, 4-3, 4-4	21.480(4)	21.497(4)	21.469(4)	21.067(4)	21.001(4)	20.835(4)

LSD Values

n_1 \ n_2	α = .05		α = .10	
	2	4	2	4
2	.568	.492	.469	.407
4	.492	.402	.407	.332

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - HMPGA

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	10.708	2.142	8.166	.000
Groups	1	3.501	3.501	.137	.730
Models	2	1,085.123	542.562	21.283	.007
FxG	5	1.542	.308	1.176	.356
FxM	10	15.143	1.514	5.775	.000
GxM	2	9.810	4.905	.192	.832
FxGxM	10	5.306	.531	2.023	.086
Cars(GxM)	4	101.972	25.493	178.735	.000
FxC(GxM)	20	5.245	.262	1.839	.136
Error	60	8.558	.143		
Total(adj)	119	1,246.906			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

Fuel

Model	Base	MG1	MG2	MG3	MG4	MG5
0, 4-1, 4-2	31.895(4)	32.492(4)	32.013(4)	32.216(4)	31.853(4)	31.484(4)
0, 6-1	26.022(2)	25.118(2)	24.217(2)	23.591(2)	23.402(2)	22.677(2)
0, 4-3, 4-4	26.457(4)	26.408(4)	26.672(4)	25.832(4)	26.216(4)	25.938(4)

Closed Loop

Fuel

Model	Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	31.108(4)	31.343(4)	30.284(4)	31.325(4)	31.465(4)	31.509(4)
C, 6-1	25.788(2)	25.393(2)	24.947(2)	24.978(2)	24.008(2)	24.352(2)
C, 4-3, 4-4	26.268(4)	26.246(4)	26.311(4)	25.568(4)	25.567(4)	25.138(4)

LSD Values

	$\alpha = .05$		$\alpha = .10$	
n_1 \ n_2	2	4	2	4
2	1.068	.925	.883	.765
4	.925	.755	.765	.625

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - MPGA

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	5.425	1.085	17.083	.000
Groups	1	17.915	17.915	6.344	.065
Models	2	361.319	180.660	63.970	.001
FxG	5	.431	.086	1.358	.282
FxM	10	4.526	.453	7.126	.000
GxM	2	29.144	14.572	5.160	.078
FxGxM	10	1.437	.144	2.263	.058
Cars(GxM)	4	11.297	2.824	23.020	.000
FxC(GxM)	20	1.270	.064	.518	.948
Error	60	7.361	.123		
Total(adj)	119	440.126			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

	Fuel					
Model	Base	MG1	MG2	MG3	MG4	MG5
0, 4-1, 4-2	23.285(4)	23.208(4)	23.170(4)	23.101(4)	22.984(4)	22.625(4)
0, 6-1	19.371(2)	18.638(2)	18.442(2)	17.436(2)	18.078(2)	17.458(2)
0, 4-3, 4-4	18.832(4)	18.900(4)	18.723(4)	18.460(4)	18.643(4)	18.577(4)

Closed Loop

	Fuel					
Model	Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	21.037(4)	21.567(4)	20.713(4)	21.187(4)	21.224(4)	20.924(4)
C, 6-1	19.253(2)	18.623(2)	19.052(2)	18.115(2)	18.573(2)	18.146(2)
C, 4-3, 4-4	18.693(4)	18.725(4)	18.661(4)	18.415(4)	18.324(4)	18.278(4)

LSD Values

	α = .05		α = .10	
n_1 \ n_2	2	4	2	4
2	.526	.455	.435	.377
4	.455	.372	.377	.307

APPENDIX G

DETAILED RESULTS OF ANALYSIS OF VARIANCE

TABLE F-4. TEST ABORT AND REJECTION CRITERIA

CATEGORY	REASON FOR REJECTION
Test Condition	-Background HC or CO concentrations exceed 10 ppm. -Test or soak temperatures exceed the prescribed 20-30°C (68-86°F). -Soak time (key-off to key-on) >12 hrs or <36 hrs.
Equipment Failure	-Unstable instrument traces. -Unstable dynamometer load (post-cal exceeds ±1 HP). -Unstable zero or span calibrations (post-cal exceeds ±1.0 deflection). -CVS or bag leaks (propane recovery of > 98%). -Test-cell computer. -Driver's-aid recorder (post-cal exceeds ±1 mph). -Instrument recorders. -Power or other utility.
Operator/Driver Procedure	-Incorrect calibration procedure,including calibrating to incorrect standard, failing to perform calibration, or failing to adequately document calibration. -Incorrect test procedures, including driver trace violations and shift points not attributable to vehicle operation, failure to use correct starting procedure, wrong fuel or fuel hook-up, and failing to use prescribed procedures.
Vehicle Operation	-Brake failure -Mechanical failure, i.e., cooling system, electrical, etc.
Emission Data	-Obvious incorrect data not traceable to clerical error. -Diurnal time versus temperature limits exceeded.
Miscellaneous	-Running out of bag sample (maybe due to instrument failure or procedure). -Incorrect maintenance procedure or part installation. -Preconditioning procedure rejected. -Roll or CVS revolution counts outside of tolerance limits. -Other reasons not easily categorized.

system leaks ruled out, so that emissions performance was clearly due to fuel effects.

F.3 TEST DATA

Calibration and test data were recorded on data sheets and strip charts. The data for each test were compiled into a data packet by test personnel and submitted to Quality Control. Data were audited, approved, and processed as required by SCI Quality Control Personnel.

Calibration and test data were audited in accordance with procedures used on emission test programs. The criteria are based on requirements contained in the CFR generally, and specifically reflected procedures required of EPA-contract laboratories. Where special procedures were involved, i.e., performance testing and alcohol/aldehyde determinations, acceptance criteria were established by the Analytical Procedures Subpanel of the CRC Alternative Automotive Fuels Group. Table F-4 summarizes data-audit criteria.

chart. The coastdown times were then averaged, and the average time was divided into the appropriate constant to determine equivalent actual horsepower. The allowable horsepower tolerance was eight percent of nominal horsepower. If the computed actual horsepower differed by more than eight percent from the nominal horsepower, new coastdown calibrations were performed by using a straight-line fit between the coastdown-check data point and data points obtained by running coastdowns at 2.5 horsepower above and below the existing indicated horsepower.

F.2.2.4 Monthly Calibration of SHED

Calibrations on the SHED were performed monthly following initial checkout, using the calibrations procedures as described in 40 CFR, Part 86.117-78. In addition, volume calibration checks, background, and retention checks were also performed by GC. The initial and monthly background emissions were less than 0.4g for the four-hour evaluation period, and the initial and monthly HC retention check agreed within two percent of the injected propane mass at the end of the check period.

F.2.2.5 Analytical Laboratory

Calibration checks of the analytical laboratory equipment and procedures used for aldehyde and alcohol determinations were checked periodically during this test program. Components used for standards preparation and recovery tests were assayed for purity. Compressed gases used for standardizing the gas chromatograph were checked periodically against pure-component injections. The spectrophotometer calibration curve was developed for each batch of MBTH reagent and checked for consistency with previous curves. Curves were repeated if the results were not consistent or if the curve was not reasonably linear. Recovery tests of known components were also performed several times during testing in order to verify overall system performance.

F.2.3 Vehicle Preparation

Vehicles were prepared for tests in a manner which minimized vehicle variability as much as possible. Fuel was drained from fittings placed in the bottom of each tank. This ensured that as much fuel as possible was actually drained from the tank. Fuel was stored under refrigeration and dispensed directly from drums into the vehicle. A volumetric metering system was used to automatically and accurately dispense fuels. The fuel tank was left open during draining and filling to ensure that the canister was not accidently charged or purged during fueling.

The carbon canisters were preconditioned as described in Section 4 prior to each vehicle test in order to reduce variability in evaporative emissions caused by adsorption of alcohols and hydrocarbons on the activated carbon. Without preconditioning, it was expected that the canister system would show a "memory" from one fuel to the next. Because of this memory, base fuel tests were performed before alcohol tests.

At the end of each phase of evaporative-emission tests, the sources of evaporative emissions were identified using a probe connected to the FID hydrocarbon detector. Using this technique, hydrocarbon and alcohol emission sources (fuel cap, quick-connects, etc.) were identified and possible fuel-

- Sample System: Record HC, CO, and CO_2 zero potentiometer, span potentiometer, and tune values. Record NO_2 gain potentiometer values. Record HC fuel, air, and sample pressures. Record results of HC hang-up procedure to determine sample-bag and sample-line contamination.

- NO_x-Converter Efficiency Check: Perform and record NO_x-converter efficiency check on 0 to 100ppm range.

- Constant Volume Sampler (CVS): Inlet and outlet pressures are recorded, within the range of the initial calibration, and consistent with prior data.

- Propane Recovery Test: Perform and record propane recovery test after completing all other checks.

- Working Gas Cylinders Pressures: Record all cylinder pressures and verify that they exceed 100psig. Any cylinders with less than 100psig were replaced.

F.2.2.2 Weekly Calibration Curve Checks

Analytical instrument calibration curve checks were performed weekly after preventative maintenance and prior to initiating any tests for the week. The calibration curve checks were performed on every range of each instrument. The curve check was performed by calibrating the instrument on the highest one percent NBS traceable gravimetric standard gas using the existing calibration curve. The remaining laboratory standard gases used for that range (five standard gases) were then read. The allowable tolerance for the instrument response on the midpoint gases plus or minus one percent of full-scale or two percent of true concentration as defined by the certification tag label. Curves which were within this tolerance continued to be used. Curves which were not within this tolerance were discarded. New calibration curves were used, or instrument malfunctions, if any, were corrected. New calibration curves were developed any time a laboratory standard gas was replaced. Linear least-square error regression equations were used for HC and NO_x instrument ranges. Fourth-order polynomial least-square error regression equations were used for CO and CO_2 instrument ranges.

Working gases used for instrument span adjustments were named from the calibration curve. Working gases were also checked and renamed if their response differed by more than plus or minus one percent of full-scale from the existing curve.

F.2.2.3 Biweekly Dynamometer Coastdowns

Dynamometer-coastdown calibration checks were performed biweekly after preventative maintenance and prior to initiation of testing. Coastdown checks consisted of five coastdown procedures for each load and inertia weight used in the test program. Coastdown checks were performed by setting the dynamometer to the existing indicated horsepower and then performing five replicate coastdowns from 55 mph to 45 mph. The coastdown speeds were recorded on a recorder operating at a chart speed of one inch per second. The time of the coastdown from 55 mph to 45 mph was then measured directly from the recorder strip

TABLE F-3. CALIBRATION SCHEDULE

CALIBRATION CHECK	INITIAL AND FINAL	MONTHLY	WEEKLY	DAILY	PER TEST
Constant Volume Sampler					
1. Calibrate CVS pump	X				
2. Obtain two valid propane recovery tests	X			(1)	
Mini-CVS					
1. Calibrate flow	X				
Dynamometer					
1. Calibrate actual vs. indicated hp for each required inertia weight	X				
2. Verify actual vs. indicated hp for all required inertia weights			X	(biweekly)	
3. Calibrate speed and load meters	X		X	(biweekly)	
Instrument System					
1. Calibrate instruments with gravimetric named gases (mass analyzers only)	X		X		
2. Perform curve-fit for all instruments (mass analyzers only)	X		X		
3. Perform system leak test	X			X	X
4. Calibrate temperature recorders	X	X			
5. Calibrate driver's aid • speed vs. time • 0 and 50 mph	X				
6. Calibrate drivers-aid speed and load					X
7. Span instruments with "working" gases (pre- and post-test cal.)					X
SHED					
1. Background and volume calibration	X	X			
2. HC retention check	X	X			
Analytical Laboratory Equipment					
1. Standardized GC's	X				X
2. Verify spectrophotometer using stock solutions	X				

TABLE F-2. SUMMARY OF RECOVERY TESTS

	EXHAUST EMISSIONS			SHED EMISSIONS	
	Ethanol	Aldehyde	Methanol	Ethanol	Methanol
Number of Tests	10	17	12	6	15
Average (%)	91	96	93	97	101
Standard Deviation (%)	9	13	15	4	17
Coefficient of Variation (%)	10	14	16	4	16

5 ml of ethanol injected during both phases of SHED test and Bag 1 of exhaust test

5 ml of methanol injected during both phases of SHED test and Bag 3 of exhaust test

1 ml of formaldehyde injected during Bag 2 of the exhaust test

TABLE F-1. SUMMARY OF CRC LABORATORY-CHECKOUT CRITERIA

SYSTEM OR INSTRUMENT	ACCEPTANCE CRITERIA
General Facility	Soak-area size, fuel storage and handling facilities, gas-cylinder storage, soak-temperature control, and test-cell humidity and test-cell control.
Dynamometers	Compliance with specifications, coastdown repeatability, load stability, roll-speed calibration, roll-diameter measurement.
Driver's Aids	Chart speed, recorder linearity and deadband, zero and span stability, verification of driving schedule against Federal Register specifications.
Constant Volume Samplers	Flow-rate calibration, LFE traceable to NBS, propane recovery tests, lack of mixing-chamber stratification, exhaust-pipe pressures, temperature regulation, sample-bag contamination or leaks.
Analytical Instruments	Leak checks, compliance with specification for calibration curves, lack of interferences, response times, stability.
SHED	Retention and propane recovery tests
Analytical Laboratory	90% recovery of known ethanol, methanol, and aldehyde concentrations in exhaust and SHED samples
Record Keeping	Maintenance logs, preventive-maintenance plan, test logs, calibration logs.
Test Procedures	Observation of testing.

F.1.3 Demonstration Testing

As a final part of checkout, a series of demonstration tests were performed to show test repeatability and the ability to recover known quantities of formaldehyde, ethanol, and methanol injected into the sampling system. Table F-2 summarizes the final recovery data obtained prior to start of testing.

Demonstration tests were observed by members of the Analytical Methods and Emission Test Procedures Panel of the Alternative Automotive Fuels Group on two different occasions. Recommendations were made to SCI for improving recovery and repeatability of aldehyde and alcohol detection. These recommendations were adopted with the resulting improvement in laboratory performance.

F.2 PROCEDURAL PRECAUTIONS

Throughout the program, a number of precautions were followed to provide maximum accuracy in the test results. These included:

- Preventative maintenance
- Periodic calibration
- Vehicle preparation

F.2.1 Preventative Maintenance

SCI provided an extensive program of preventative maintenance of laboratory equipment throughout the program. The maintenance program included: 1) weekly checks of instrument and dynamometer electro-mechanical component, inspection, and functional test sample system components; 2) biweekly lubrication and inspection of CVS and dynamometer mechanical components; and 3) monthly calibration and inspection of recorders. Preventative maintenance and, when required, troubleshooting and corrective maintenance, were performed by SCI's staff of instrumentation engineers and technicians.

F.2.2 Periodic Calibrations

Periodic calibration and performance checks were performed throughout the program. Table F-3, Calibration Schedule, illustrates the routine calibration and performance checks and their frequency. These checks were performed after the preventative maintenance described above. Additional calibrations and performance checks were also performed after unscheduled instrument-maintenance activities, or if unreasonable calibration or emission data were obtained.

Scheduled calibrations and checks were performed monthly, biweekly, weekly, and daily as illustrated in Table F-3. The procedures were performed as prescribed by the Code of Federal Regulations. A brief summary of these calibration checks is presented below.

F.2.2.1 Daily Equipment Checks

- System Leak Test: Perform and record satisfactory recovery of a known-concentration gas injected into each fully-evacuated sample bag.

Appendix F

QUALITY ASSURANCE

This appendix describes measures taken to ensure that the test results were accurate and precise. Separate paragraphs address the following topics:

- Laboratory Checkout
- Procedural Precautions
- Test Data

F.1 LABORATORY CHECKOUT

After completion of all facility modifications required for testing, an extensive checkout of all equipment, instruments, and procedures was undertaken before testing was allowed to begin.

F.1.1 Equipment Calibration

Checkout included developing calibrations for dynamometer coastdowns, instruments, and CVS. The data developed were reviewed by SCI Quality Control personnel to ensure compliance with requirements. Table F-1 summarizes the criteria for accepting instrument calibrations. Checkout of Test Cell 1 was completed after the test program had started, but before tests were performed in that cell.

F.1.2 Personnel Training

Emission test procedures, including sampling and analysis for ethanol, methanol, and aldehydes, were reviewed with test technicians prior to initiating tests. Although basic test procedures were the same as routinely performed, several special considerations were involved in this program, including:

- Vehicle fueling and draining
- Carbon canister preconditioning
- Fluidyne installation and use during dynamometer tests
- Sampling for aldehydes and alcohols
- Vapor lock procedures
- Analysis of aldehyde and alcohol samples

Procedures for this test program were prepared and distributed to test personnel before beginning testing. Emission testing was conducted on one shift with occasional overlap onto a second shift. Vapor lock testing was performed on second and third shifts. Procedures were reviewed with shift supervisors and technicians. Many practice tests under the direction of the SCI project manager and test engineer were performed in order to familiarize the staff with the complete test sequence.

APPENDIX F

QUALITY ASSURANCE

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - ENECA

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	1,000.066	200.013	39.523	.000
Groups	1	1,416.051	1,416.051	6.306	.066
Models	2	28,804.471	14,402.236	64.136	.001
FxG	5	25.805	5.161	1.020	.432
FxM	10	441.363	44.136	8.721	.000
GxM	2	2,310.950	1,155.475	5.146	.078
FxGxM	10	106.293	10.629	2.100	.076
Cars(GxM)	4	898.229	224.557	22.690	.000
FxC(GxM)	20	101.214	5.061	.511	.951
Error	60	593.806	9.897		
Total(adj)	119	35,698.249			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

	Fuel					
Model	Base	MG1	MG2	MG3	MG4	MG5
0, 4-1, 4-2	202.655(4)	203.398(4)	200.782(4)	209.252(4)	207.625(4)	210.073(4)
0, 6-1	168.587(2)	163.351(2)	159.806(2)	157.934(2)	163.308(2)	162.104(2)
0, 4-3, 4-4	163.902(4)	165.648(4)	162.246(4)	167.214(4)	168.408(4)	172.489(4)

Closed Loop

	Fuel					
Model	Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	183.092(4)	189.022(4)	179.493(4)	191.910(4)	191.728(4)	194.279(4)
C, 6-1	167.564(2)	163.214(2)	165.092(2)	164.086(2)	167.780(2)	168.484(2)
C, 4-3, 4-4	162.686(4)	164.112(4)	161.708(4)	166.800(4)	165.531(4)	169.714(4)

LSD Values

	α = .05		α = .10	
n_1 \ n_2	2	4	2	4
2	4.693	4.064	3.880	3.360
4	4.064	3.318	3.360	2.744

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - HENECA

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	2,102.473	420.495	21.661	.000
Groups	1	269.643	269.643	.133	.733
Models	2	86,701.600	43,350.800	21.459	.007
FxG	5	115.538	23.108	1.190	.349
FxM	10	1,643.143	164.314	8.464	.000
GxM	2	783.820	391.910	.194	.831
FxGxM	10	431.048	43.105	2.220	.062
Cars(GxM)	4	8,080.589	2,020.147	181.403	.000
FxC(GxM)	20	388.251	19.413	1.743	.051
Error	60	668.175	11.136		
Total(adj)	119	101,184.279			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

Model	Fuel: Base	MG1	MG2	MG3	MG4	MG5
0, 4-1, 4-2	277.591(4)	284.771(4)	277.406(4)	291.810(4)	287.738(4)	292.334(4)
0, 6-1	226.474(2)	220.142(2)	209.856(2)	213.683(2)	211.396(2)	210.553(2)
0, 4-3, 4-4	230.261(4)	231.451(4)	231.122(4)	233.980(4)	236.820(4)	240.834(4)

Closed Loop

Model	Fuel: Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	270.741(4)	274.694(4)	262.422(4)	283.742(4)	284.234(4)	292.566(4)
C, 6-1	224.434(2)	222.549(2)	216.180(2)	226.248(2)	216.875(2)	226.106(2)
C, 4-3, 4-4	228.620(4)	230.029(4)	227.998(4)	231.597(4)	230.957(4)	233.404(4)

LSD Values

n_1 \ n_2	$\alpha = .05$: 2	$\alpha = .05$: 4	$\alpha = .10$: 2	$\alpha = .10$: 4
2	9.191	7.960	7.599	6.581
4	7.960	6.499	6.581	5.373

ANALYSIS OF FUEL AND ENERGY ECONOMY DATA - ENECOMB

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	1,341.498	268.300	45.899	.000
Groups	1	1,080.348	1,080.348	2.522	.187
Models	2	44,416.387	22,208.193	51.840	.001
FxG	5	39.290	7.858	1.344	.287
FxM	10	670.714	67.071	11.474	.000
GxM	2	1,832.775	916.387	2.139	.233
FxGxM	10	164.184	16.418	2.809	.024
Cars(GxM)	4	1,713.600	428.400	55.440	.000
FxC(GxM)	20	116.910	5.846	.756	.752
Error	60	463.634	7.727		
Total(adj)	119	51,839.339			

Table of Means: Fuels x Groups x Models (n_{ijk} in Parentheses)

Open Loop

Model	Fuel: Base	MG1	MG2	MG3	MG4	MG5
0, 4-1, 4-2	230.652(4)	233.394(4)	229.277(4)	239.760(4)	237.339(4)	240.512(4)
0, 6-2	190.486(2)	184.804(2)	179.018(2)	178.942(2)	181.932(2)	180.828(2)
0, 4-3, 4-4	188.319(4)	189.942(4)	187.361(4)	191.843(4)	193.556(4)	197.736(4)

Closed Loop

Model	Fuel: Base	MG1	MG2	MG3	MG4	MG5
C, 4-1, 4-2	214.151(4)	219.584(4)	209.030(4)	224.479(4)	224.446(4)	228.804(4)
C, 6-1	189.118(2)	185.464(2)	184.701(2)	187.234(2)	186.810(2)	190.292(2)
C, 4-3, 4-4	186.946(4)	188.405(4)	186.042(4)	190.824(4)	189.708(4)	193.451(4)

LSD Values

	α = .05		α = .10	
n_1 \ n_2	2	4	2	4
2	5.044	4.368	4.170	3.611
4	4.368	3.566	3.611	2.949

ANALYSIS OF EMISSIONS DATA - ORGANIC

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	.069	.014	4.034	.011
Groups	1	.346	.346	8.049	.047
Models	2	.101	.050	1.171	.398
FxG	5	.030	.006	1.770	.165
FxM	10	.046	.005	1.361	.266
GxM	2	.183	.091	2.126	.235
FxGxM	10	.064	.006	1.879	.110
Cars(GxM)	4	.172	.043	11.754	.000
FxC(GxM)	20	.068	.003	.931	.553
Error	60	.220	.004		
Total(adj)	119	1.300			

Table of Means: Fuels (n_i=20, $LSD_{.05}$ = .038, $LSD_{.10}$ = .032)

Fuel:	MG1	MG3	MG5	MG2	MG4	Base
$\bar{y}_i$:	.252	.278	.282	.285	.314	.325

Table of Means: Groups (n_j = 60, $LSD_{.05}$ = .105, $LSD_{.10}$ = .081)

Group:	Open	Closed
$\bar{y}_j$:	.235	.343

ANALYSIS OF EMISSIONS DATA - CARBON MONOXIDE (CO)

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	50.490	10.098	10.213	.000
Groups	1	69.428	69.428	3.680	.128
Models	2	122.545	61.272	3.248	.145
FxG	5	8.273	1.655	1.673	.187
FxM	10	14.084	1.408	1.424	.240
GxM	2	7.850	3.925	.208	.820
FxGxM	10	12.714	1.271	1.286	.302
Cars(GxM)	4	75.464	18.866	24.935	.000
FxC(GxM)	20	19.776	.989	1.307	.211
Error	60	45.397	.757		
Total(adj)	119	426.021			

Table of Means: Fuels (n_i=20, $LSD_{.05}$ = .656, $LSD_{.10}$ = .542)

Fuel:	MG3	MG5	MG1	MG4	MG2	Base
$\bar{y}$:	2.549	2.581	3.176	3.323	3.807	4.382

ANALYSIS OF EMISSIONS DATA - NITROGEN OXIDES (NO_x)

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	1.597	.319	5.275	.003
Groups	1	19.208	19.208	23.009	.009
Models	2	.920	.460	.551	.615
FxG	5	.184	.037	.609	.694
FxM	10	1.065	.107	1.759	.136
GxM	2	.744	.372	.446	.669
FxGxM	10	.837	.084	1.382	.257
Cars(GxM)	4	3.339	.835	30.094	.000
FxC(GxM)	20	1.211	.061	2.184	.011
Error	60	1.664	.028		
Total(adj)	119	30.770			

Table of Means: Fuels (n_i=20, $LSD_{.05}$= .162, $LSD_{.10}$ = .134)

Fuel:	Base	MG2	MG1	MG4	MG3	MG5
$\bar{y}_i$:	.978	1.105	1.135	1.236	1.264	1.327

Table of Means: Groups (n_j = 60, $LSD_{.05}$ = .463, $LSD_{.10}$ = .356)

Group:	Open	Closed
$\bar{y}_j$:	1.574	.774

ANALYSIS OF EMISSIONS DATA - ALDEHYDES

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	318.785	63.757	.809	.557
Groups	1	141.484	141.484	1.572	.278
Models	2	3,091.167	1,545.584	17.168	.011
FxG	5	551.185	110.237	1.400	.267
FxM	10	1,372.512	137.251	1.743	.139
GxM	2	197.795	98.898	1.099	.417
FxGxM	10	394.465	39.447	.501	.870
Cars(GxM)	4	360.116	90.029	1.126	.353
FxC(GxM)	20	1,575.314	78.766	.986	.492
Error	60	4,796.805	79.947		
Total(adj)	119	12,799.630			

Table of Means: Models

Model:	0, C, 4-3, 4-4	0, C, 4-1, 4-2	0, C, 6-1
$\bar{y}_k(n_k)$:	14.281(48)	16.198 (24)	27.646(48)

LSD Values

$n_1 \backslash n_2$	$\alpha = .05$ 24	$\alpha = .05$ 48	$\alpha = .10$ 24	$\alpha = .10$ 48
24	7.605	6.586	5.839	5.057
48	6.586	5.377	5.057	4.129

ANALYSIS OF EMISSIONS DATA - METHANOL

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	2,634.552	526.910	10.428	.000
Groups	1	402.967	402.967	2.868	.166
Models	2	1,370.938	685.469	4.878	.085
FxG	5	220.534	44.107	.873	.517
FxM	10	1,254.174	125.417	2.482	.040
GxM	2	198.551	99.275	.706	.546
FxGxM	10	687.864	68.786	1.361	.267
Cars(GxM)	4	562.096	140.524	2.797	.034
FxC(GxM)	20	1,010.569	50.528	1.006	.469
Error	60	3,014.545	50.242		
Total(adj)	119	11,356.789			

Table of Means: Fuels x Models (n_{ik} in Parentheses)

Model	Base	MG1	MG2	MG3	MG4	MG5
0, C, 4-1, 4-2	1.950(8)	6.062(8)	6.650(8)	5.975(8)	11.225(8)	11.200(8)
0, C, 6-1	-3.300(4)	21.125(4)	8.350(4)	25.500(4)	20.150(4)	22.000(4)
0, C, 4-3, 4-4	.925(8)	4.538(8)	4.050(8)	7.975(8)	13.950(8)	11.750(8)

LSD Values

n_1 \ n_2	$\alpha = .05$		$\alpha = .10$	
	4	8	4	8
4	10.485	9.080	8.669	7.507
8	9.080	7.414	7.507	6.130

ANALYSIS OF EMISSIONS DATA - SHEDORG

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	281.814	56.363	5.015	.004
Groups	1	204.308	204.308	2.809	.169
Models	2	185.099	92.550	1.272	.374
FxG	5	79.871	15.974	1.421	.259
FxM	10	73.689	7.369	.656	.751
GxM	2	114.626	57.313	.788	.515
FxGxM	10	19.394	1.939	.173	.997
Cars(GxM)	4	290.950	72.737	63.748	.000
FxC(GxM)	20	224.763	11.238	9.849	.000
Error	60	68.461	1.141		
Total(adj)	119	1,542.975			

Table of Means: Fuels (n_i = 20, $LSD_{.05}$ = 2.211, $LSC_{.10}$ = 1.828)

Fuel:	Base	MG1	MG2	MG3	MG4	MG5
$\bar{y}_i$:	2.880	4.107	4.548	5.712	6.927	7.162

ANALYSIS OF EMISSIONS DATA - SHEDMEOH

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	41.409	8.282	6.876	.001
Groups	1	13.343	13.343	2.876	.165
Models	2	4.918	2.459	.530	.625
FxG	5	11.519	2.304	1.913	.137
FxM	10	7.430	.743	.617	.782
GxM	2	4.322	2.161	.466	.658
FxGxM	10	3.626	.363	.301	.972
Cars(GxM)	4	18.556	4.639	69.918	.000
FxC(GxM)	20	24.089	1.204	18.153	.000
Error	60	3.981	.066		
Total(adj)	119	133.193			

Table of Means: Fuels (n_i = 20, $LSD_{.05}$ = .724, $LSD_{.10}$ = .598)

Fuel:	Base	MG1	MG2	MG3	MG4	MG5
$\bar{y}_i$:	.057	.530	.755	1.138	1.513	1.791

ANALYSIS OF DRIVEABILITY AND VAPOR LOCK DATA - DEMERITS

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	92,465.567	18,493.113	12.558	.000
Groups	1	149.633	149.633	.013	.914
Models	2	22,597.012	11,298.506	1.003	.444
FxG	5	5,122.567	1,024.513	.696	.633
FxM	10	20,618.662	2,061.866	1.400	.250
GxM	2	10,787.512	5,393.756	.479	.651
FxGxM	10	14,459.162	1,445.916	.982	.489
Cars(GxM)	4	45,075.375	11,268.844	21.142	.000
FxC(GxM)	20	29,451.875	1,472.594	2.763	.001
Error	60	31,981.000	533.017		
Total(adj)	119	272,708.367			

Table of Means: Fuels (n_i = 20, $LSD_{.05}$ = 25.314, $LSD_{.10}$ = 20.929)

Fuel:	Base	MG2	MG1	MG4	MG5	MG3
$\bar{y}_i$:	50.500	77.850	83.350	120.350	123.050	123.200

ANALYSIS OF DRIVEABILITY AND VAPOR LOCK DATA - VAPLOCK

ANOVA

Source	d.f.	S.S.	M.S.	F	Signif. Prob.
Fuels	5	345.879	69.176	1.931	.134
Groups	1	317.525	317.525	3.697	.127
Models	2	9,066.510	4,533.255	52.782	.001
FxG	5	206.218	41.244	1.152	.367
FxM	10	527.169	52.717	1.472	.221
GxM	2	272.964	136.482	1.589	.311
FxGxM	10	402.681	40.268	1.124	.392
Cars(GxM)	4	343.548	85.887	2.876	.030
FxC(GxM)	20	716.318	35.816	1.199	.287
Error	60	1,792.090	29.868		
Total(adj)	119	13,990.900			

Table of Means: Models (n_k in Parentheses)

Model:	Century	Horizon/Omni	Pinto
$\overline{y}_k$:	-17.992(24)	-2.021(48)	5.812(48)

LSD Values

	α = .05		α = .10	
n_1 \ n_2	24	48	24	48
24	7.427	6.432	5.703	4.939
48	6.432	5.251	4.939	4.033

APPENDIX H

FUEL AND ENERGY ECONOMY: SEPARATE HIGHWAY AND CITY FTP RESULTS

TABLE H-1. SUMMARY OF ANALYSIS OF VARIANCE RESULTS

	EFFECT				
	FUEL	FUEL×GROUP	FUEL×MODEL	FUEL×GROUP×MODEL	FUEL×CAR
FTP FUEL ECONOMY	X		X	X	X
HIGHWAY FUEL ECONOMY	X		X	X	
FTP ENERGY ECONOMY	X		X	X	
HIGHWAY ENERGY ECONOMY	X		X	X	X

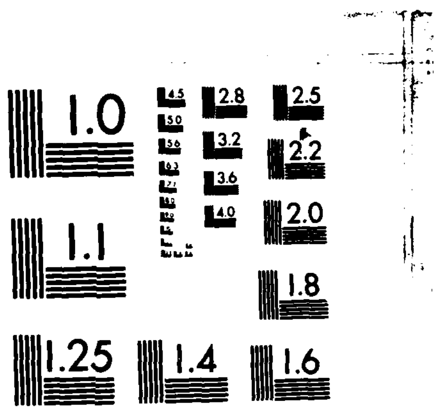
"X" INDICATES EFFECTS FOUND SIGNIFICANT AT 0.10 SIGNIFICANCE LEVEL

AD-A159 893 PERFORMANCE EVALUATION OF ALCOHOL-GASOLINE BLENDS IN 1980 MODEL AUTOMOBIL.. (U) COORDINATING RESEARCH COUNCIL INC ATLANTA GA JAN 84 CRC-536 DAAK70-81-C-0128

3/3

UNCLASSIFIED F/G 21/4 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE H-2. SUMMARY OF MEANS FOR DATA GROUPS DEFINED BY ANALYSIS OF VARIANCE RESULTS

	CAR MODEL	CAR GROUP	FUEL BASE	02B0	02B1	05B0	05B3	08B2
FTP FUEL ECONOMY, MPG	C	CLOSED	19.25	19.05	18.62	18.57	18.11	18.15
	C	OPEN	19.37	18.44	18.64	18.08	17.44	17.46
	O	CLOSED	21.04	20.71	21.57	21.22	21.19	20.92
	O	OPEN	23.29	23.17	23.21	22.98	23.10	22.62
	P	CLOSED	18.69	18.66	18.73	18.32	18.41	18.28
	P	OPEN	18.83	18.72	18.90	18.64	18.46	18.58
HIGHWAY FUEL ECONOMY, MPG	C	CLOSED	25.79	24.95	25.39	24.01	24.98	24.35
	C	OPEN	26.02	24.22	25.12	23.40	23.59	22.68
	O	CLOSED	31.11	30.28	31.34	31.46	31.33	31.51
	O	OPEN	31.90	32.01	32.49	31.85	32.22	31.48
	P	CLOSED	26.27	26.31	26.25	25.57	25.57	25.14
	P	OPEN	26.46	26.67	26.41	26.22	25.83	25.94
FTP ENERGY ECONOMY, MI/MBTU	C	CLOSED	167.56	165.09	163.21	167.78	164.09	168.48
	C	OPEN	168.59	159.81	163.35	163.31	157.93	162.10
	O	CLOSED	183.09	179.49	189.02	191.73	191.91	194.28
	O	OPEN	202.65	200.78	203.40	207.62	209.25	210.07
	P	CLOSED	162.69	161.71	164.11	165.53	166.80	169.71
	P	OPEN	163.90	162.25	165.65	168.41	167.21	172.49
HIGHWAY ENERGY ECONOMY, MI/MBTU	C	CLOSED	224.43	216.18	222.55	216.87	226.25	226.11
	C	OPEN	226.47	209.86	220.14	211.40	213.68	210.55
	O	CLOSED	270.74	262.42	274.69	284.23	283.74*	292.57
	O	OPEN	277.59	277.41	284.77	287.74	291.81	292.33
	P	CLOSED	228.62	228.00	230.03	230.96	231.60	233.40
	P	OPEN	230.26	231.12	231.45	236.82	233.98	240.83

* DIFFERENCES NOT SIGNIFICANT AT 0.1 SIGNIFICANCE LEVEL.

NOTE: This table is computer-generated and, on occasion, the number of significant digits exceeds what is justified by the experimental program.

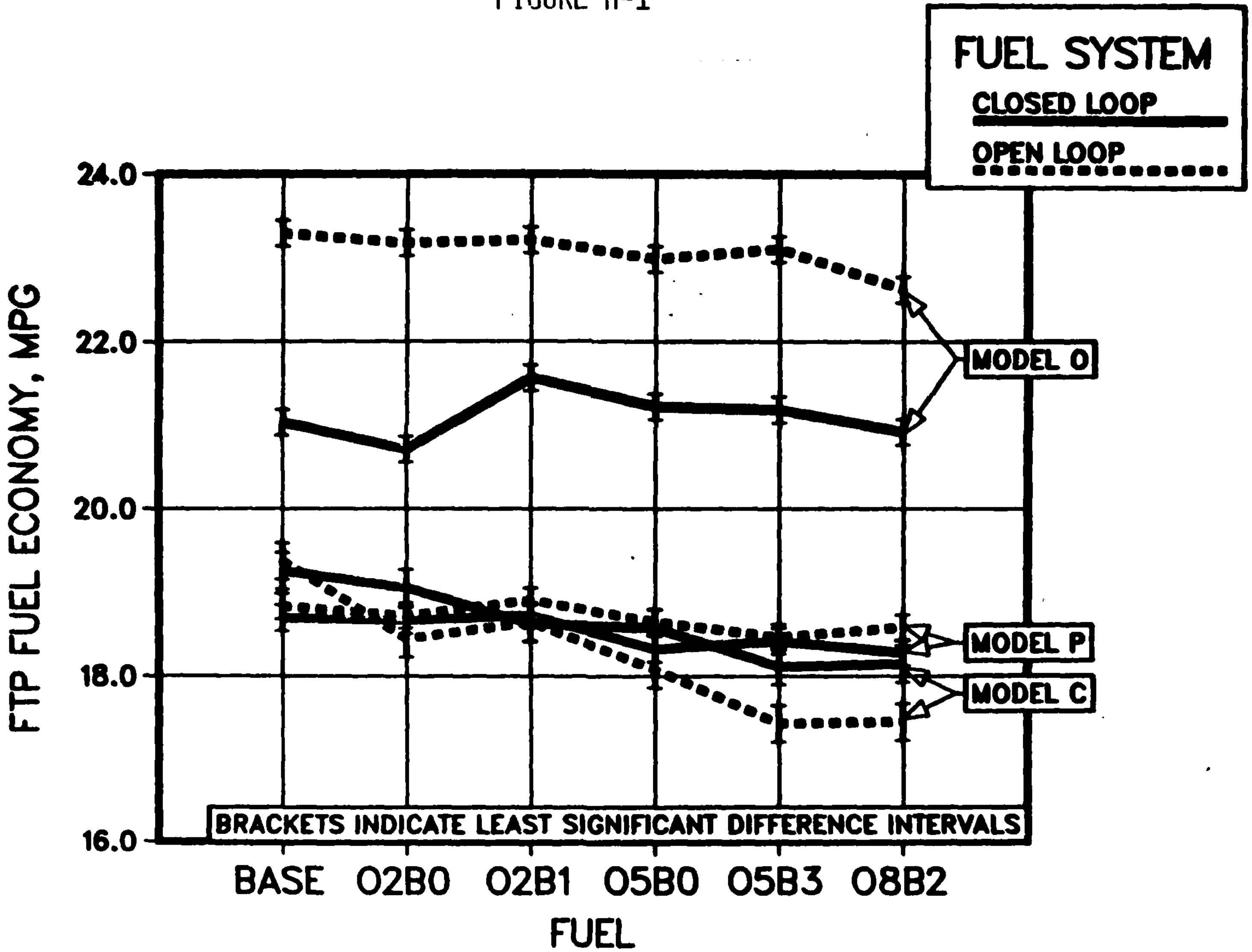
TABLE H-3. SIGNIFICANT CHANGES FOR SELECTED FUEL PAIRS

	CAR MODEL	CAR GROUP	FUEL PAIRS 02B0 VS. BASE	02B1 VS. BASE	05B0 VS. BASE	05B3 VS. BASE	08B2 VS. BASE	02B1 VS. 02B0	05B3 VS. 05B0	05B0 VS. 02B0
FTP ENERGY ECONOMY, MI/MBTU	C	CLOSED	NS	-4.35	NS	NS	NS	NS	NS	NS
	C	OPEN	-8.78	-5.24	-5.28	-10.65	-6.48	NS	-5.38	NS
	O	CLOSED	-3.60	5.93	8.64	8.82	11.19	9.53	NS	12.24
	O	OPEN	NS	NS	4.97	6.60	7.42	NS	NS	6.84
	P	CLOSED	NS	NS	2.84	4.11	7.03	NS	NS	3.82
	P	OPEN	NS	NS	4.51	3.31	8.59	3.40	NS	6.16
HIGHWAY ENERGY ECONOMY, MI/MBTU	C	CLOSED	-8.25	NS	NS	NS	NS	NS	9.37	NS
	C	OPEN	-16.62	NS	-15.08	-12.79	-15.92	10.29	NS	NS
	O	CLOSED	-8.32	NS	13.49	13.00	21.82	12.27	NS	21.81
	O	OPEN	NS	7.18	10.15	14.22	14.74	7.37	NS	10.33
	P	CLOSED	NS	NS	NS	NS	NS	NS	NS	NS
	P	OPEN	NS	NS	6.56	NS	10.57	NS	NS	5.70
FTP FUEL ECONOMY, MPG	C	CLOSED	NS	-0.63	-0.68	-1.14	-1.11	NS	-0.46	-0.48
	C	OPEN	-0.93	-0.73	-1.29	-1.93	-1.91	NS	-0.64	NS
	O	CLOSED	-0.32	0.53	NS	NS	NS	0.85	NS	0.51
	O	OPEN	NS	NS	NS	NS	-0.66	NS	NS	NS
	P	CLOSED	NS	NS	-0.37	NS	-0.41	NS	NS	-0.34
	P	OPEN	NS	NS	NS	-0.37	NS	NS	NS	NS
HIGHWAY FUEL ECONOMY, MPG	C	CLOSED	NS	NS	-1.78	NS	-1.44	NS	0.97	-0.94
	C	OPEN	-1.80	-0.90	-2.62	-2.43	-3.35	0.90	NS	NS
	O	CLOSED	-0.82	NS	NS	NS	NS	1.06	NS	1.18
	O	OPEN	NS	NS	NS	NS	NS	NS	NS	NS
	P	CLOSED	NS	NS	-0.70	-0.70	-1.13	NS	NS	-0.74
	P	OPEN	NS	NS	NS	-0.63	NS	NS	NS	NS

"NS" INDICATES DIFFERENCES NOT SIGNIFICANT AT 0.1 SIGNIFICANCE LEVEL.

NOTE: This table is computer-generated and, on occasion, the number of significant digits exceeds what is justified by the experimental program.

FIGURE H-1


FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL O
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
24.0
22.0
20.0
18.0
16.0
FTP FUEL ECONOMY, MPG
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

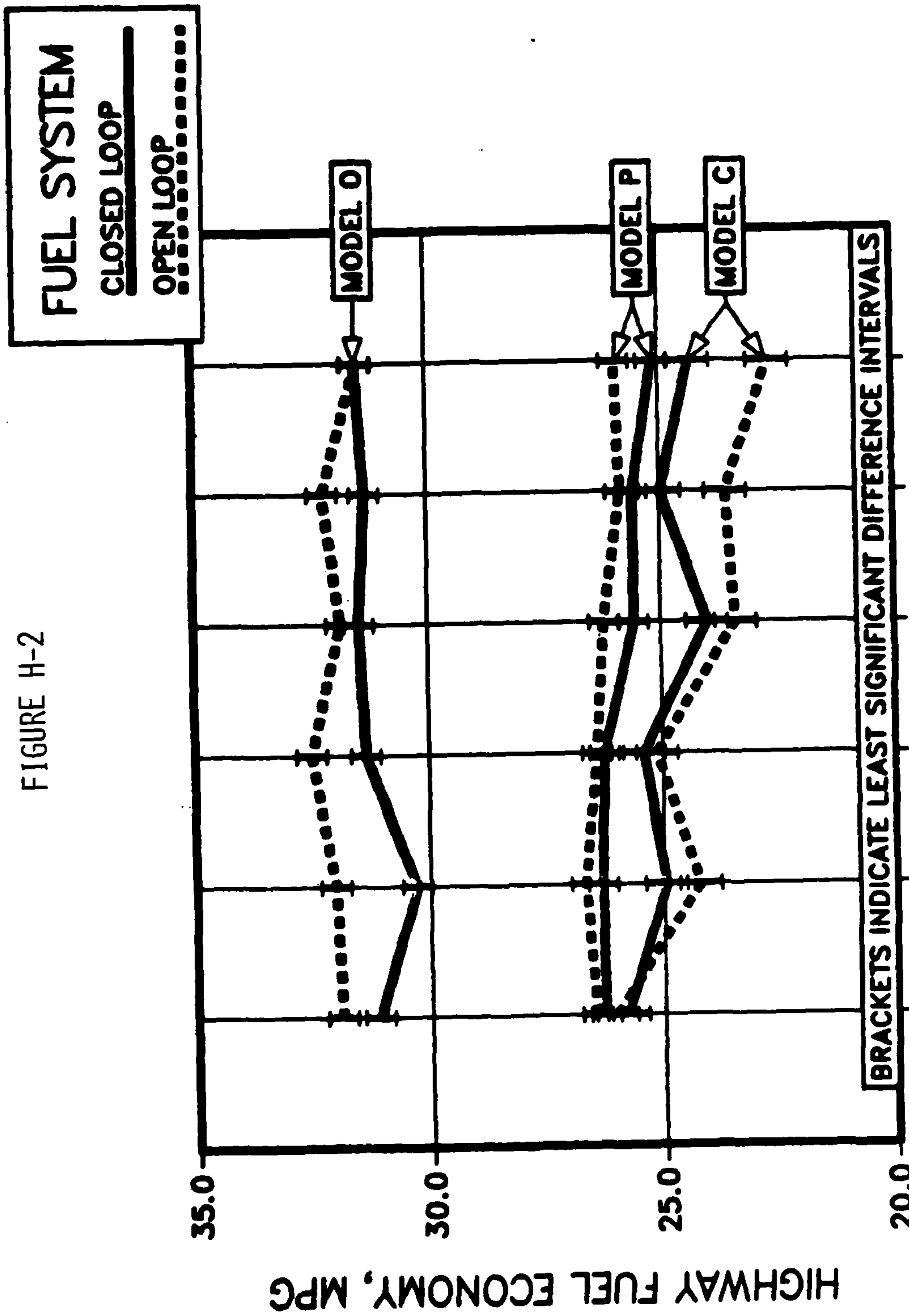
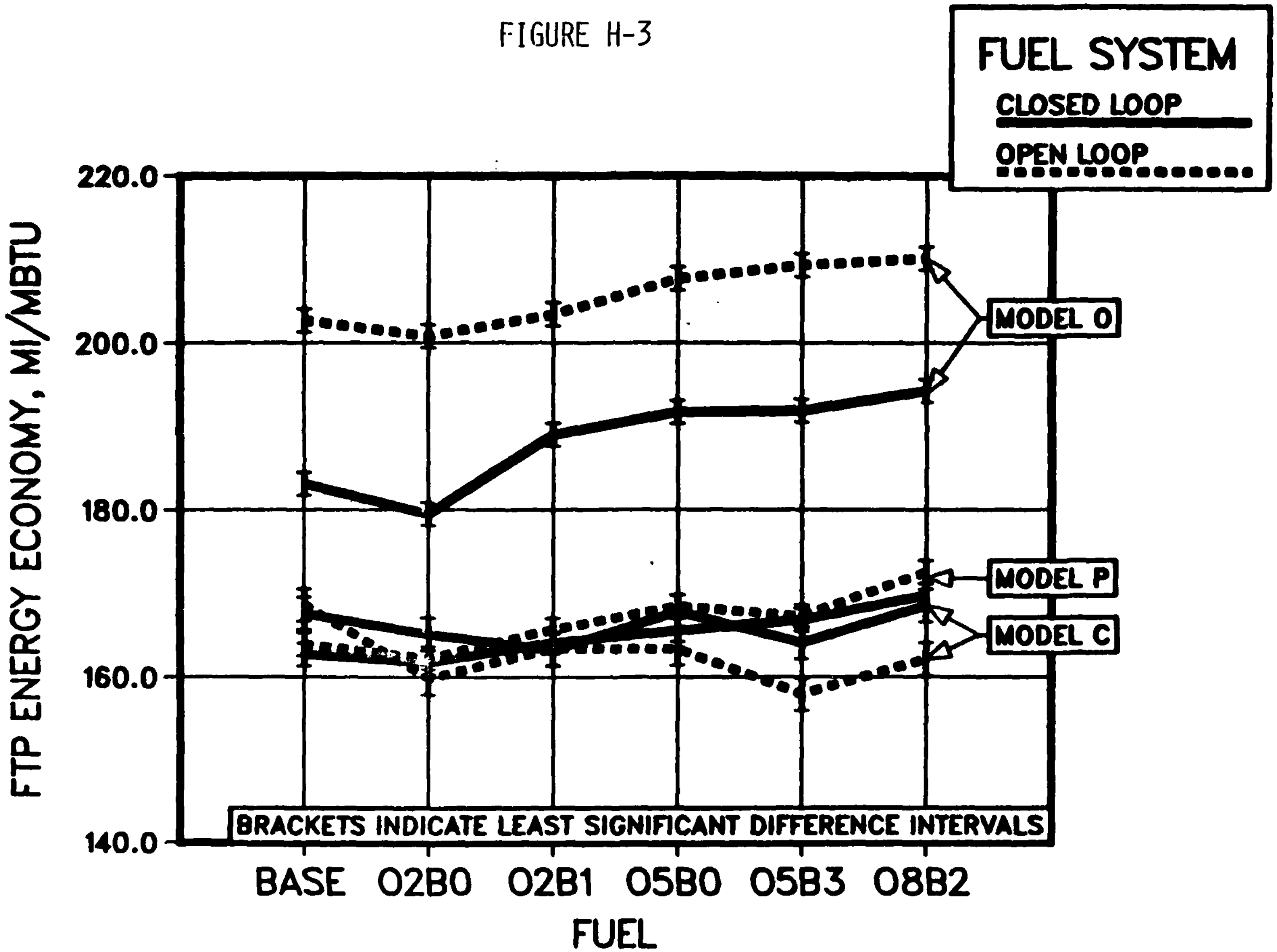

FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL D
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
35.0
30.0
25.0
20.0
HIGHWAY FUEL ECONOMY, MPG
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

FIGURE H-2

FIGURE H-3


FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL O
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
FTP ENERGY ECONOMY, MI/MBTU
220.0
200.0
180.0
160.0
140.0
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

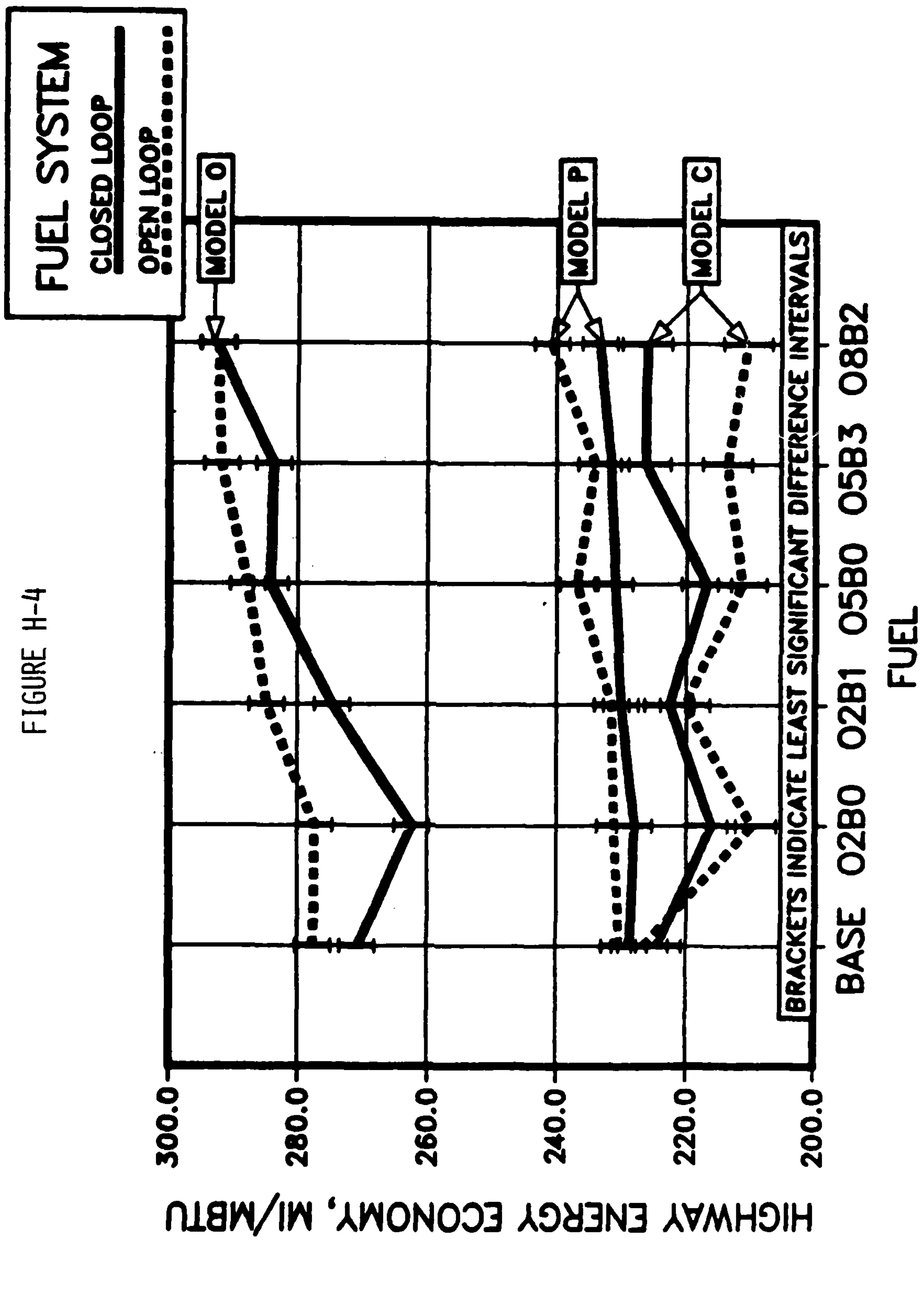

FUEL SYSTEM
CLOSED LOOP
OPEN LOOP
MODEL O
MODEL P
MODEL C
BRACKETS INDICATE LEAST SIGNIFICANT DIFFERENCE INTERVALS
300.0
280.0
260.0
240.0
220.0
200.0
HIGHWAY ENERGY ECONOMY, MI/MBTU
BASE
O2B0
O2B1
O5B0
O5B3
O8B2
FUEL

FIGURE H-4

END

FILMED

11-85

DTIC